• TRADING TRADE SECRETS • WHEN AUTOMATION STIFLES PRODUCTIVITY •

• THUROW ON COMPUTERS AND THE CRASH •

Technology Review

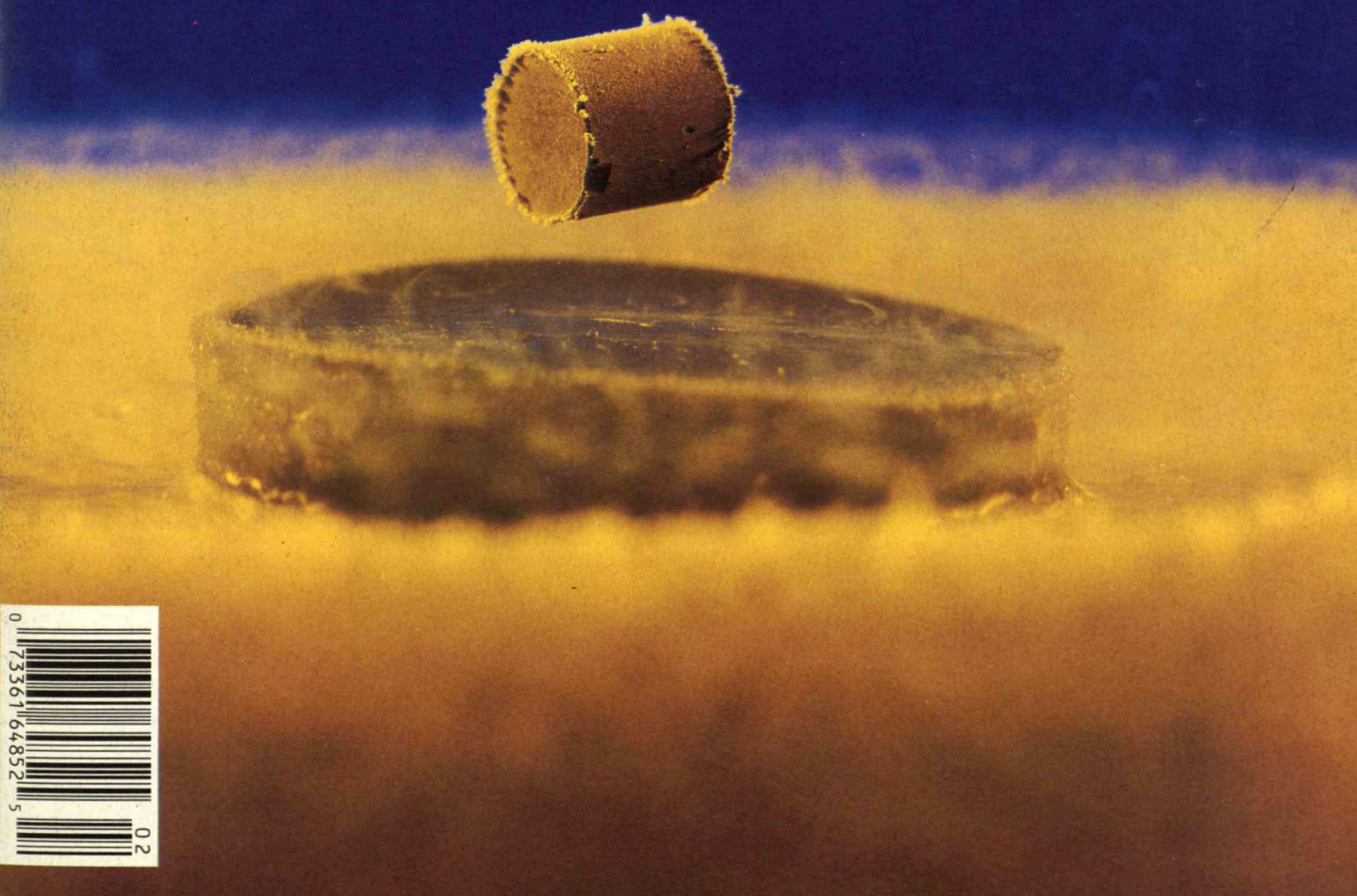
EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FEBRUARY/MARCH 1988

$3.00

SUPERCONDUCTORS:

THE UNCERTAIN FUTURE FOR PRACTICAL TECHNOLOGIES



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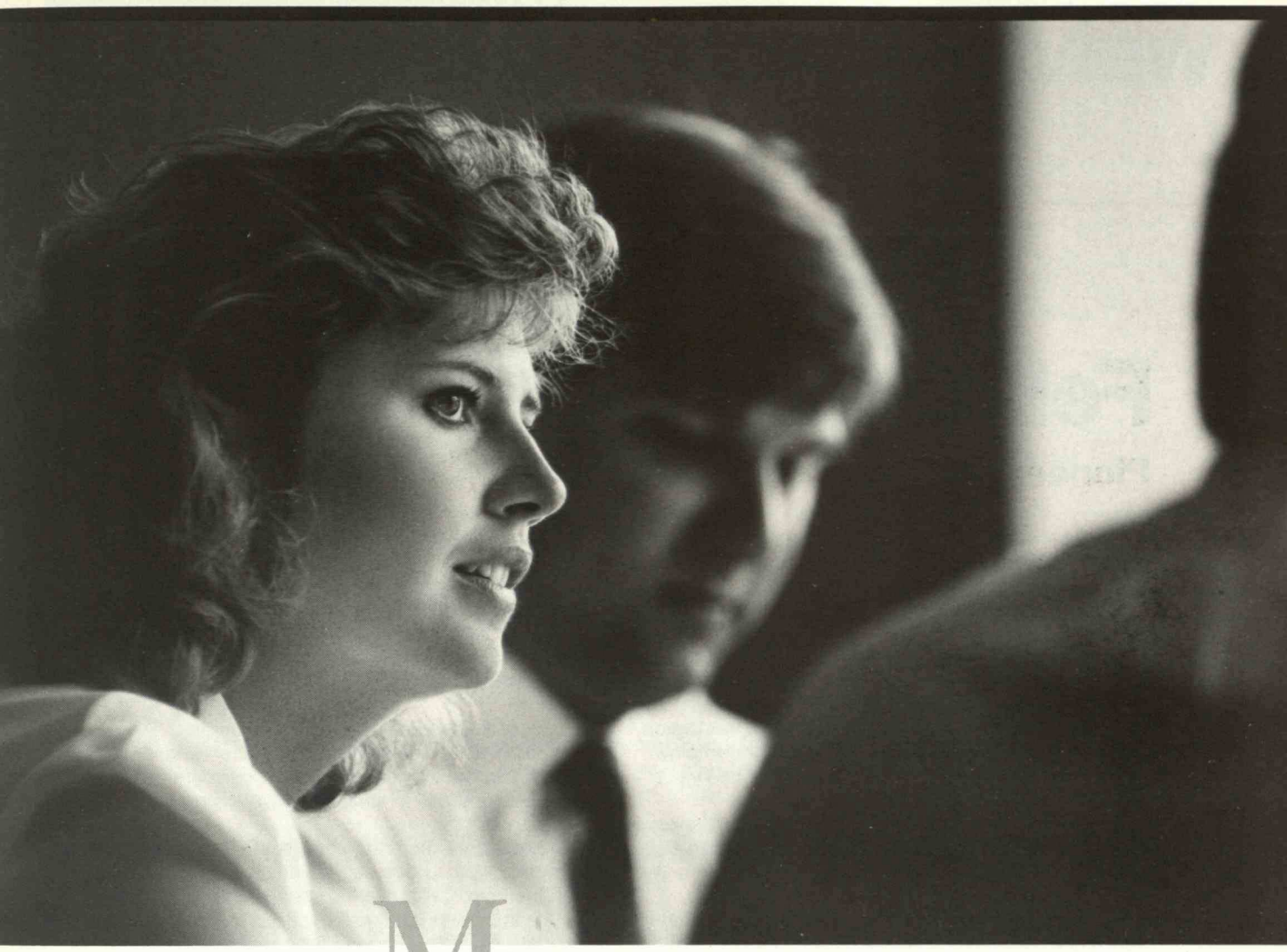

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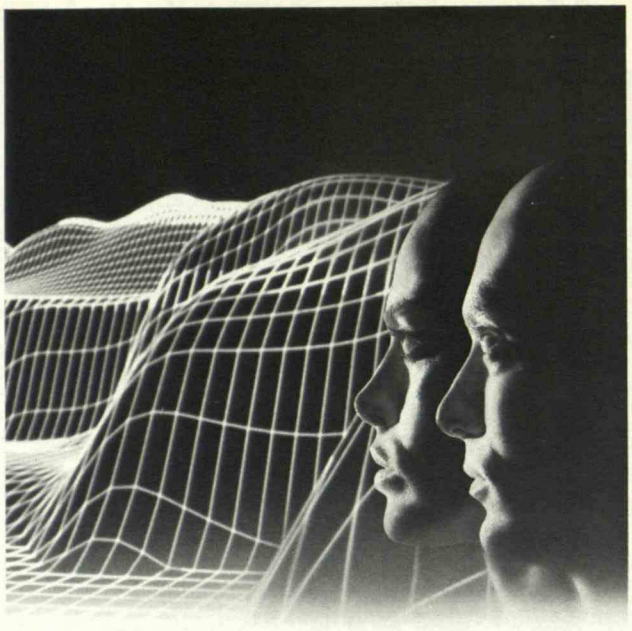

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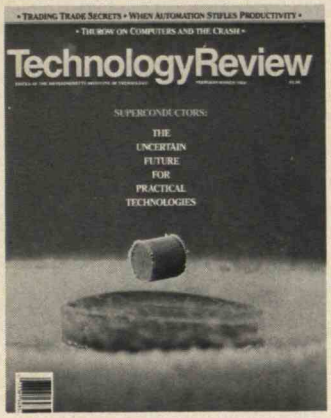

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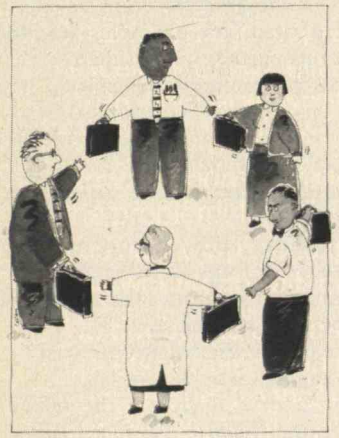

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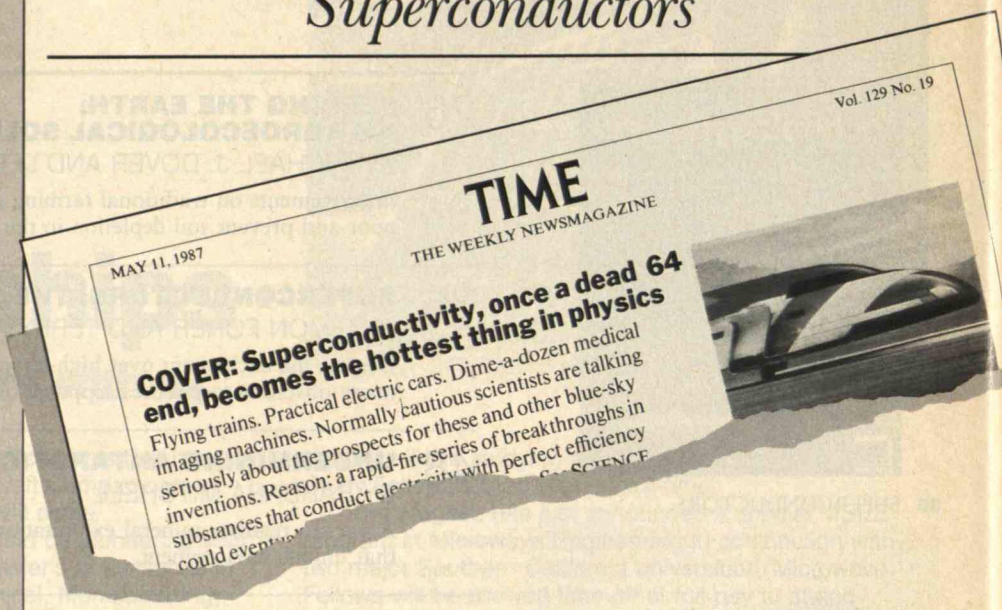
FIRST LINE

FROM THE EDITOR

Moving Faster on Superconductors



In this issue Simon Foner and Terry Orlando provide *Technology Review* with our first major article on what may well be the landmark technology of the 1990s—higher-temperature superconductors (*see page 36*). As our authors point out, the pace of research on these materials has been breathtaking, and the excitement has generated some extravagant promises about such applications as magnetically levitated (MAGLEV) trains, low-cost power transmission, and vastly more powerful electronics. Our authors urge caution. Superconductivity is not yet a robust technology, and it is not really possible to know how it will be used.

Indeed, it is hard even to forecast the way in which the new developments—and there inevitably will be some—will occur. But some important observations on this issue came recently from a colleague of our authors, H. Kent Bowen, a professor in ceramic and electrical engineering at M.I.T. He emphasizes the need for new strategies that couple basic research, development, and industrial application far more closely than is traditional in materials science.

When it comes to high-temperature superconductors, the Japanese have some inherent advantages, Bowen told the House Committee on Science, Space, and Technology last year. Few American companies can match the resources of the giants of Japanese industry. "Our companies are not so effectively integrated . . . and our record in commercializing new materials has not been what it could have been," Bowen told the lawmakers.

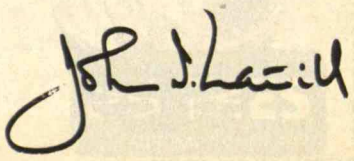
In contrast, several Japanese makers of electric cable have resources especially appropriate to ceramic superconductors, and many Japanese electronics firms have "substantial technical and production resources in the area of ceramics," Bowen said. He cited, for example, Sumitomo Electric: its partner in the superconductor business is Sumitomo Chemical, which Bowen described as maker of "some of the finest continuous aluminum-oxide fibers available"—and therefore, he said, well positioned for innovation on superconducting fibers.

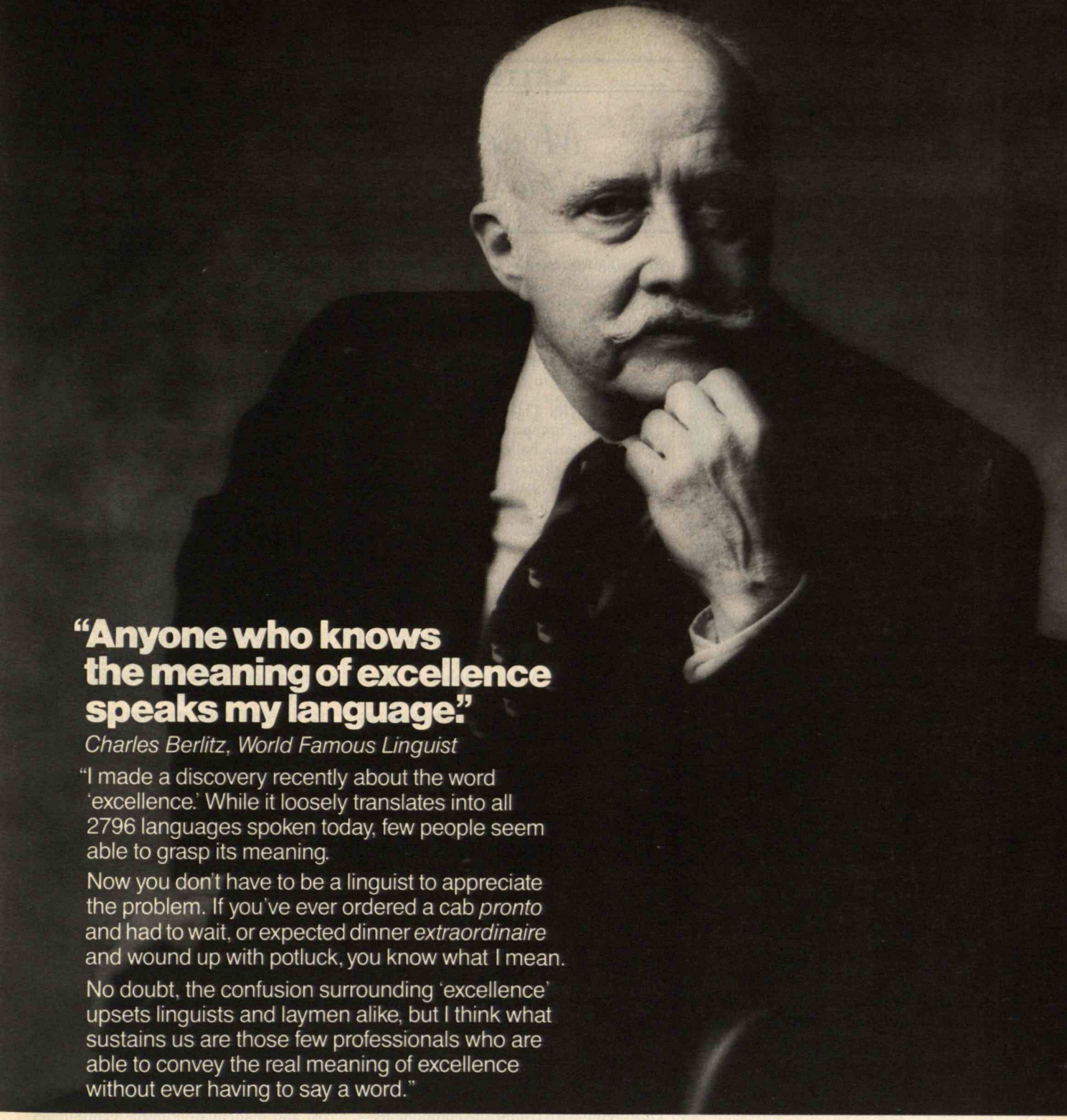
On balance, Bowen concluded, the United States "appears to be at a serious disadvantage for joining the right people with the right technologies."

To help right the balance, Bowen made two recommendations:

☐ Form a new agency in the image of DARPA (the Defense Advanced Research Projects Agency) to create a high-temperature superconductor industry in the United States.

☐ Mount a concerted effort to speed the process by which radically new materials technologies are moved from laboratory to commercial use in the United States. At least 10 years have typically been required, but in the case of high-temperature superconductors that would be too long.





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Modern War, New Materials

FOREIGN-POLICY MEMORY LANE

In "Ambiguous War" (*August/September 1987, page 60*), Marc S. Miller defines low-intensity conflict (LIC) as a new doctrine and emphasizes its role in Latin America. But it sounds to me like a retread of failed policies from the past.

For example, like LIC, the advisor program in Vietnam and the old "police training" in Latin America both used local forces armed and trained by the United States for our foreign-policy aims. Police training organized groups within governments to act independently against labor and human-rights groups. If free labor and destruction of democratic governments are U.S. foreign-policy objectives, then these projects were very successful. The National Guard of Somoza's Nicaragua was the result of one of them. The effects of police training are also evident in El Salvador and Guatemala.

Another major difficulty with contemporary LIC in Latin America is poor goal definition. This same shortcoming characterized our bungled campaigns in Vietnam and Beirut.

The idea that we have a new way of approaching situations is just a palliative. It helps us ignore the real problems in our policies.

CARL W. MILLER
Los Angeles, Calif.

The author responds:

Carl Miller is partially right in noting that LIC is a close relative of past U.S. errors. This brings up the question of why policymakers choose to rename old, unpopular ideas.

But while LIC has historical roots, it is new. It unites economic, humanitarian, and military aid much more carefully and cynically than did Vietnam-era counterinsurgency tactics in its effort to combat movements that enjoy great popular support. LIC depends on a low profile because it contradicts the principles of self-determination for other nations, and because it calls for actions contrary to U.S. public opinion. Even more important, to hide from controversy at home and abroad, LIC requires that others fight our wars, whether it's contras in Nicaragua or a surrogate military in El Salvador.

ALCHEMY IN THE 1980s

Thanks for Thomas Eagar's insightful article "The Real Challenge in Materials Engineering" (*February/March 1986, page 24*). I especially liked the emphasis on better-quality and lower-cost processing as a means of becoming more competitive.

ROLAND LAU
Columbia, S.C.

I object to Thomas Eagar's suggestion that "the hunt for new materials should remain primarily the province of academic and government laboratories." Luckily, it has never been our nation's policy to direct research in this manner.

If the world had waited for the academic community to embrace polymer science, we would not have the plastics, fibers, and elastomers that have become essential to our modern lifestyle. Industrial scientists are a prime source of technological innovation, and it is an insult to their creativity to restrict them to building on the discoveries of academic and government workers.

FRANK WEIGERT
Cambridge, Mass.

Thomas Eagar says that "no one is mass-producing aircraft frames with composites," and that "most composites will remain high-performance, high-cost materials for limited markets such as the military." These broad and far-reaching statements are incorrect.

There are a number of commercial aircraft flying with composite components—among them the Boeing 747 and 767. Also, the Beech Aircraft Starship, whose airframe is constructed mainly of composites, may receive certification from the Federal Aviation Administration within the year.

PAUL A. LAGACE
Cambridge, Mass.

Thomas Eagar maintains that we can make polymers as strong as steel because we have quantum mechanics to guide us. Baloney! Chemists, not materials engineers, are responsible for wonders such as polymers. Quantum theory is essential for some things, but it's not a panacea.

While reading another part of the article, I thought my knowledge of chemical physics had failed me. I couldn't understand how electrons in a sodium atom could have 23 energy levels. Then I figured it out. Eagar had confused the atomic weight of sodium (23) with its atomic number (11).

Also, Eagar is wrong to say that carbon-carbon bonds, as in diamond, are the strongest known. Silicon-oxygen bonds, as in quartz, are stronger. Graphite, the thermodynamically more stable form of carbon, probably has stronger bonds as well.

EDWIN A. CHANDROSS
Murray Hill, N.J.

The author responds:

I agree with Mr. Weigert that industrial scientists have contributed greatly to technological innovation, but I am not sure that they have done much to discover new materials with unusual properties. As for the failure of U.S. universities to embrace polymer science, I can only state that academics in this country follow a free-market philosophy. If materials science departments have helped companies like IBM and AT&T more than they have helped chemical companies, perhaps it is because the former have supported them while the latter have sent their resources to chemical engineering departments. After all, if you ignore people long enough, they might choose to snub you in return.

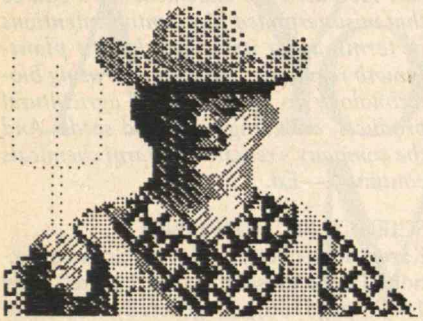
One of my primary reasons for writing my article was to debunk the oversell that people such as Mr. Lagace perpetrate. Composites are the materials of the future, and they have been for over 30 years. Until the people working in this field recognize that they must solve the problems of high cost and inadequate joining technologies, composites will remain the materials of the future for many more years.

I suggest that Mr. Chandross reread my section on quantum theory. I never used the word panacea. In addition, there is more to materials science than organic chemistry. While quantum theory may not have helped the chemist a great deal, it is responsible for much of what we understand about the properties of electronic materials, metals, and ceramics.

I regret the error about the atomic weight of sodium atoms, which occurred in an explanatory passage that a *Tech-*

nology Review editor added. I should have proofread the edited manuscript more carefully.

As for the strengths of bonds, I think one should define terms. Strength means something different to a chemist than to a materials engineer. I'll stand by my statement that carbon-carbon bonds are the strongest, but that is just because my definition of strength is not necessarily the same as a chemist's would be.



THE REAL ISSUE IN FARMING

In "Time to Retrain the American Farmer" (*May/June 1987, page 22*), Lester Thurow misses the point when he deals with the farm issue as if the future will be like the recent past. In fact, farmers may see dramatic decreases in production levels because of topsoil erosion from over-cultivation, shortages in fossil fuels and petrochemical fertilizers, and shifts in rainfall belts because of the greenhouse effect.

The real farm problem is determining how to change to a form of agriculture we can sustain. Today's system rewards the overuse of land, depletion of finite resources, and damage to the environment.

STEPHEN POMERANCE
Boulder, Colo.

AIDS AND PREJUDICE

Jeffrey E. Harris's otherwise interesting and informative article "The AIDS Epidemic: Looking into the 1990s" (*July 1987, page 58*) is tragically marred by a blatant display of prejudice against intravenous drug users and, most especially, gay and bisexual men. When this scientist performs a statistical analysis of the incidence of AIDS, he produces a potentially important work. When he proceeds, however, to find that the "danger" lies in "heterosexuals giving the infection to each other" and gives priority to "preventing a heterosexual epidemic," he has already trespassed into the realm of anti-gay prejudice. Although the subject of his study is the spread of AIDS among heterosexuals, he goes too far in suggesting that the distinction between heterosexuals and homosexuals should be incorporated into public policy.

We suggest that the danger lies in selecting "acceptable" AIDS victims, and in allowing "people who test positive for the AIDS virus" to "become an underclass in our society." The danger also lies in failing to combat AIDS, wherever it strikes, with education, medical research, and respect for human dignity. If we do not avoid these dangers, we run the risk of fighting one another and not the disease.

D. DANIEL STERNBERGH
Cambridge, Mass.

Sternbergh's letter is written on behalf of the executive board of Gays at M.I.T.

The author responds:

Mr. Sternbergh's letter does not accurately describe my article.

I wrote that even if there is no heterosexual epidemic, "the total number of AIDS cases will be large enough to place a severe burden on our health-care and insurance systems as well as our society at large" by the 1990s.

I also wrote that people who test positive for AIDS "will need special help from our society." Nowhere does my article speak of "acceptable" victims.

Still, I agree with Mr. Sternbergh's main point: we need to "combat AIDS, wherever it strikes, with education, medical research, and respect for human dignity."

ELECTROMAGNETIC DANGERS

The issues Louis Slesin raises in "Power Lines and Cancer: The Evidence Grows" (*October 1987, page 52*) require careful consideration. I would like to point out one more possible danger from non-ionizing radiation: that of sleeping under an electric blanket. This may be harmful because of the close proximity of the blanket to the stomach and the rather lengthy exposure to electromagnetic fields. Also, like high-voltage power lines, electric blankets usually have supply and return wires that are not twisted around one another. As a result, the magnetic field is perhaps 10 times greater than it would otherwise have to be.

Observations on the electric-blanket ef-

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CONTINUED FROM PAGE 5

fect, largely anecdotal, started about 15 years ago and led to a grant request to the National Institutes of Health. The idea was for a study correlating cancer of the stomach with use of electric blankets. The data were to be noted by attending physicians at cancer hospitals. Unfortunately, the request was not approved.

DONALD K. ROSS
St. Louis, Mo.

There is no question that the effects of electromagnetic radiation upon biological systems deserve full investigation. In addition, all other frequencies of electromagnetic radiation should be studied. This includes the radio and television broadcast frequencies bathing the biosphere.

RICHARD C. BENTINCK
Carson City, Nev.

MIDDLE EASTERN BOMBS

In "The Nuclear Arsenal in the Middle East" (*May/June 1987, page 27*), Frank Barnaby suggests that we should rely on the 1970 Nuclear Non-Proliferation Treaty (NPT). But unfortunately, the NPT does not provide a solution to the problem of nuclear weapons in the Middle East or anywhere else. As Nigel Calder explains in *Nuclear Nightmares*, the treaty can be circumvented simply by running a separate military program that is not subject to safeguards. Moreover, any nation can renounce the treaty by giving three months' notice before formal withdrawal.

Another approach to the Middle East nuclear-weapons problem would be to impose a moratorium on the shipment of all nuclear technology to nations in the area. The superpowers could also agree not to introduce nuclear weapons, either directly or indirectly, into any conflict there. The long-term goal would be a nuclear-weapon-free zone. Israel proposed such a zone to the United Nations General Assembly on June 9, 1981.

J. RICHARD SHANEBROOK
Schenectady, N.Y.

THE TRUTH ABOUT MONSANTO

From what is reported in the July 1987 issue, one would assume that Monsanto Co. is developing a split personality. In "Chemicals: An Industry Sheds Its Smokestack Image" (*page 36*), Michael J. Bennett and Charles H. Kline claim that the company is focusing on developing new agricultural products such as improved seeds. Yet David Ehrenfeld asserts in "Beyond the Farming Crisis" (*page 46*) that Monsanto is among those "starting to dump their biotechnology and farm-chemical research units." What should the reader conclude?

JEROME J. SCHMITT
New Haven, Conn.

We're pleased that you read Technology Review *so carefully. In fact, Ehrenfeld points out that his article contains an error. He based his statement on a source that misinterpreted Monsanto's intentions in terminating its research into plant-growth regulators. Monsanto is using biotechnology to develop new agricultural products, including improved seeds. And the company's research on farm chemicals continues.—Ed.*

SCIENCE FICTION LINGO

Karen Rosenberg's "Soviet Science Fiction: To the Present Via the Future" (*July 1987, page 66*), is generally excellent. However, I would like to point out that the term "sci fi" is never used by science-fiction fans or within the genre itself. It is purely a media expression.

DAVID A. HARDY
Birmingham, England

SDI SET STRAIGHT

Peter Clausen and Michael Brower, the authors of "The Confused Course of SDI" (*October 1987, page 60*), request the following correction of an error in their article. They write, "We were wrong to suggest that fast-burn boosters carry a smaller payload than standard boosters largely because the booster casing must be strengthened to withstand higher pressure from the more rapidly burning fuel. If the casing must be strengthened, it is because of greater acceleration and aerodynamic forces. The most important payload penalties for fast-burn boosters are increased atmospheric drag and stability problems. What this means is that additional aerodynamic control surfaces or other measures are required. The pressure within the rocket casing may be the same in fast-burn boosters as in standard boosters, but the nozzle area is increased to provide the greater thrust. (Thanks to our colleagues Richard Garwin and Bob Dietz.)"

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DNA Fingerprinting

The arrest last September in England of a man charged with raping and murdering two women has highlighted the almost stealthy entry of "DNA fingerprinting" or "genetic marking" into forensic science. Law-enforcement officials are confident that the new technique will soon be widely used, particularly in rape cases and paternity suits.

British law-enforcement officials took advantage of a type of DNA fingerprinting that was developed by the British Home Office and University of Leicester geneticist Alec Jeffreys in the early 1980s. The suspect was arrested after an analysis of his blood and saliva revealed a 30-billion-to-one probability that his DNA matched the DNA in semen at the scene of the crimes. Earlier, the same technique had cleared the leading police suspect.

The Jeffreys test looks at sectors in DNA known as "hypervariables." Jeffreys found that an individual's hypervariable DNA pattern is so special that only two people in perhaps hundreds of millions have the same one.

DNA fingerprinting is important because although conventional blood tests have become increasingly sophisticated in pinpointing individuals, the same cannot be said for semen samples. Traditional methods often can't determine more than blood type from semen stains.

The new approach uses DNA from blood, skin, hair, or semen. With now-common microbiology techniques, it is cut into fragments by enzymes. These fragments are combined with radioactive bits of other DNA so that each hypervariable sector leaves a print of dark bands on film. The sequence of these bands, which shows how the DNA's four component proteins are arranged, is the fingerprint.

In the United States, the most notable application of genetic markers occurred in a Pennsylvania murder case settled in 1987. The prosecution alleged that the defendants had switched the victim's organs after the autopsy. But enough DNA remained to demonstrate that no switch had taken place.

While murder cases attract news, the most widespread application of DNA fingerprinting has been in parenthood and immigration cases. This use is possible because a child's DNA is an identifiable amalgam of hypervariables from the mother and father. Genetic markers have resolved more than 500 paternity cases in the United States and about 70 immigration cases in England.

The Jeffreys test was originally developed to determine the biological parents of a Ghanaian child seeking entry into Britain. The approach indicated a greater than 99 percent degree of probability that the child was born to a woman living in England and not to one of her sisters in Africa. Thus, the child was legally eligible to live in England. The analysis could be done without DNA from the father.

Bar Code for Babies

Advocates of DNA fingerprinting say one of its advantages is the ease with which it can be explained to a jury. "It's just like a bar code in a supermarket," says Peter Gill, one of the Home Office researchers who developed the Jeffreys technique. "Everyone is different and we just match them up."

Equally important, the test does not produce a false identification if the DNA in the sample has decomposed. Instead, in Gill's words, the result is "just a smear." Moreover, the tests need not be made immediately. Jeffreys says that four-year-old stains containing less than a third of a drop of semen give fingerprints that would be repeated in only one person in every 20 million. And genetic markers theoretically could identify two different types of semen if a double rape has been alleged.

Other DNA fingerprinting technologies with potential legal applications loom on the horizon. Microbiologist Barry Glickman of York Uni-

Only two people in hundreds of millions share the same "DNA fingerprint." This pattern can be recorded as dark bands on film.

PHOTOS: WOODFIN CAMP & ASSOCIATES; MICHAEL LANGE

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versity in Toronto is designing a DNA mutation fingerprint. He has found that different substances create unique patterns of mutations in bacterial cells.

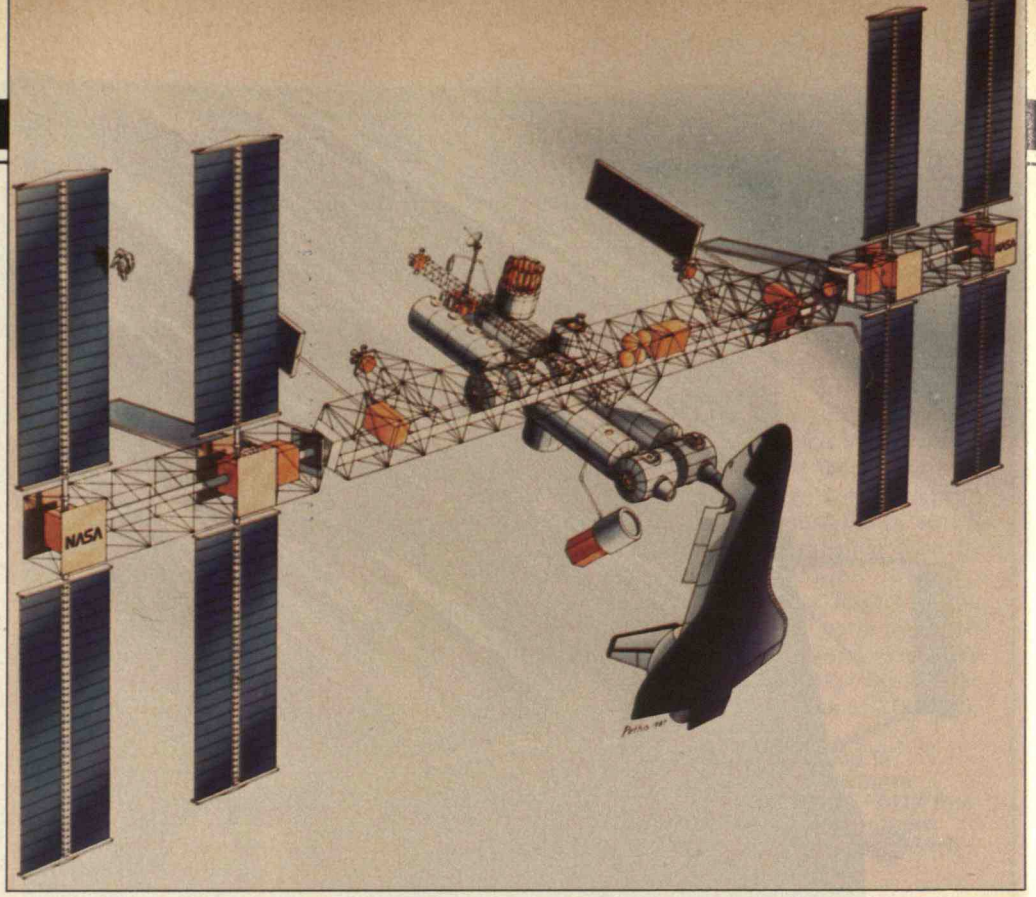
If such patterns could be discerned with accuracy in human cells, they could provide evidence that exposure to particular substances caused a cancer or other disease. Glickman points out that in liability cases now—such as those brought by textile and asbestos workers—defense lawyers can argue that genetic damage can't be attributed to a particular offending substance.

As forensic experts explore the applications of DNA fingerprinting, they are also raising civil-liberties questions about its present and possible future uses. For example, a Canadian proposal that the army create a "DNA dog tag" could cause some problems. Samples of every soldier's blood would be stored and used to identify parts of dead bodies after battles or accidents. But DNA fingerprint records would have to be protected from indiscriminate use by law-enforcement officials and others.

Moreover, compulsory large-scale testing of possible crime suspects—or any individuals—might be unconstitutional in the United States. A suggestion that convicted sex offenders provide blood samples as a condition for parole could provoke objections on such grounds.

Forensics professor George Sensabaugh of the University of California at Berkeley further points out that the tests are fallible. Even if a DNA fingerprint could be duplicated in only one person out of every 20 million, the possibility of a mistake still exists. □

STEPHEN STRAUSS is a reporter for the Globe and Mail *in Toronto, Canada.*



Phase I of the space station would feature a horizontal truss to which labs, living quarters, and solar panels would be attached.

Science or Subsidy?

December was a cheery month for NASA's Office of the Space Station—but a gloomy one for scientists who consider the project misguided. The agency selected four major aerospace firms to build the U.S. share of the project, and NASA officials were optimistic that they would soon reach an informal agreement with its three principal international partners—the European Space Agency (ESA), Japan's National Space Development Agency, and the Canadian government.

NASA hopes to start construction in 1994. It expects the process to take three years and at least 19 shuttle missions. Plans for the first phase call for a long I-shaped boom, studded with solar panels, to be placed in an equatorial orbit about 250 kilometers high. In the second phase—still tentative—NASA would likely add two more booms, increase the station's electricity, and add facilities to service satellites.

Cost estimates for even the first phase vary widely. NASA places the figure between $14 billion and $20 billion. Congressional Budget Office estimates for the project run to $30 billion by the year 2000.

The heart of the station would be a science lab and a dormitory for researchers and crew. Japan and the ESA would each build an additional lab, and Canada would contribute a robot crane for maintenance and for loading and unloading shuttle cargo. In the late 1990s, scientists should start conducting long-term low-gravity experiments, including research on materials, pharmaceuticals, basic chemistry, and physics. Former Defense Secretary Caspar Weinberger has demanded that NASA not restrict military applications, despite his department's lack of announced plans for specific studies.

Many researchers from the scientific disciplines that have used space in the last 30 years—astronomy, astrophysics, earth science, and space plasma physics—see little benefit in the ambitious project. In mid-September, the Space Science Board of the National Research Council warned that "space science should not be confined to the space station." In a report commissioned by the White House and NASA, the board called the phase-one design "satisfactory" but expressed concern about NASA's reliance on already overbooked shuttles. The board recommended that the agency improve the shuttle's reliability and performance, and suggested that NASA develop a heavy-lift launch vehicle by the late 1990s. It also proposed that expendable launch vehicles would do more to increase scientists' access to space.

"Scientists as a whole don't accept the argument that the facility is being built to service scientists," explains George Field, an astronomer at the Harvard-Smithsonian Center for Astrophysics and a member of the National Commis-

PHOTO: NASA

sion on Space. Field and other scientists—including Carl Sagan; James Van Allen, discoverer of the Van Allen belts; and Riccardo Giacconi, director of Johns Hopkins' Space Telescope Institute—criticized NASA's plans before a Senate appropriations subcommittee in spring 1987. Field bluntly calls the station "a make-work project for the aerospace industry."

Science or Technology?

According to Field, astronomers see no reason to attach x-ray, ultraviolet, or infrared telescopes to the station. Docking shuttles or crews doing push-ups might jitter such sensitive instruments, and dust in the station could hurt them. He also points out that a polar orbit would be far better for astronomy.

Moreover, Field notes that the two disciplines currently slated for the station are incompatible. Life scientists will study the long-term effects of space on humans, while materials scientists may try to develop crystals for electronics. But crystal growers need a very quiet environment, whereas life scientists would encourage crews to exercise and work in space.

John Bartoe, NASA's chief scientist for the space station, agrees with Field—to a point. But he says that a permanent space laboratory would allow researchers to monitor and analyze—and if necessary to modify—experiments in progress. Bartoe—whose field, solar physics, would not be well served by the station—was a payload specialist on a 1985 space-lab mission.

He contends that "getting into space is not a scientific issue. It's a technological issue." He adds, "It takes a lot of technology to do it, and that costs lots of money. But once you get a project going with technology, then you can do a lot of scientific research with it."

Bartoe suggests putting those fragile experiments requiring a quiet environment on a free-flyer—an automated platform in space. That NASA should make such a proposal now nettles critics who have long argued for unmanned instruments—whether free-flyers or satellites—saying they contribute more to space science than do the manned missions that have gobbled up 80 percent of NASA's budget. Beginning in the mid-1970s, the shuttle's cost overruns forced NASA to all but abandon science satellites.

Many scientists, and even a few at NASA, worry that the station could further damage the variety and quantity of small science projects—what one NASA scientist calls the "infrastructure for R&D in this country." Speaking off the record, he noted that big programs are under intense pressure to succeed, leading planners to "lose touch with the need to work out alternatives." He believes "the probability of a significant breakthrough is higher in small programs" that have "greater flexibility and freedom."

Joe Alexander, assistant associate administrator for scientific applications in NASA's Office of Space Science Applications, says the station will not eclipse unmanned missions, although he concedes that many scientists remain skeptical. "Some researchers were burned by the shuttle, and it is hard to turn them around," he admits. Nevertheless, he predicts, "Once we have the station up, we will sustain the confidence of the research community." □

THOMAS KIELY is a frequent contributor to Trends.

An Apple a Day

Marc Beyeler of Oakland, Calif., is careful about what his two children eat. After news stories linked daminozide, a pesticide used on apples, with cancer in test animals, "we changed our consumption patterns because of concerns for our children's health," Beyeler explains. "Now we buy only organic apple juice out of fear of cancer from daminozide."

More important, Beyeler, his children, New York State, and a coalition of environmental groups and individuals have asked the U.S. Court of Appeals to force the Environmental Protection Agency (EPA) to ban the chemical. The suit will be heard this winter, and comes after EPA denied a petition to outlaw daminozide.

Lawrie Mott, a biologist with the Natural Resources Defense Council (NRDC), calls the agency's decision "yet another example of EPA's ineptitude and industry's influence in delaying effective pesticide regulation." But Jim Lamb, a special assistant at EPA, defended the agency's progress. He says EPA "is doing as good a job as it can considering the level of resources we have." He notes that there are more than 600 active ingredients in 45,000 pesticides on the market. "EPA can provide assurances for 25 of these a year at the current pace," he adds.

Daminozide is called a pesticide, but it doesn't kill pests. Instead, it regulates the growth of apples earmarked for the fresh-produce market. It is also used on ornamental plants and peanut vines. Daminozide helps farmers grow firmer, redder, "extra fancy" grade apples. Treated apples stay on the tree longer and store better, making them available year-round—"a recent strong selling point," says Derl Derr, executive vice-president of the International Apple Institute, a trade group.

Daminozide, manufactured by the Uniroyal subsidiary of Avery, Inc., is sold under the trade name Alar. Because it permeates the fruit, it cannot be washed off or peeled away. When heated, as it is in the processing of applesauce and juice, Alar forms unsymmetrical 1,1-dimethylhydrazine (UDMH), which may be a "potent animal carcinogen," according to EPA. As Derr points out, up to 40 percent of apples grown for the fresh market end up being sold for applesauce and juice.

Although substitutes for Alar exist, none is as effective at preventing apples from falling before harvest time. An EPA ban on daminozide would be costly to apple growers and related industries: $100 million annually by apple institute estimates; $31 million, according to the agency. One reason is that apples making the "extra fancy" grade sell for as much as $400 per ton wholesale, but those sold for sauce and juice fetch as little as $90.

NRDC's Mott contends that Alar's use is largely cosmetic. She believe the public could learn to accept fruit that looks less than perfect. Derr disagrees, saying, "Consumers have gotten used to a big, bright red apple."

Dr. Martin Smith, past president of the American Academy of Pediatrics, thinks that "the benefits of daminozide appear to [go] entirely to the grower, the risks to the consumer." The academy notes children's vulnerability to environmental toxins and supports a ban on the chemical. Even EPA estimates that

Below: Since a controversy over daminozide erupted in 1985, sales of this pesticide for apples have dropped as much as 75 percent.

children are up to 14 times more at risk from daminozide than adults. While opposing an immediate ban, EPA has recently told Uniroyal that it has concerns about Alar.

Animal Testing

EPA was initially prepared to restrict the chemical based on three studies in the 1970s led by Dr. Bela Toth of the Eppley Institute in Omaha, Nebr., as well as tests conducted by the National Cancer Institute in 1978 and the air force in 1984. Toth, who has researched chemicals like daminozide for over 20 years, says without hesitation that it is "highly carcinogenic."

EPA's plans were thrown into chaos in 1985 by its own scientific advisory panel, which reviews agency decisions on pesticides. The panel criticized the Toth studies, which included giving a massive dose to laboratory animals. Uniroyal officials say that a person would have to eat 50,000 pounds of apples a day for life to consume the amount of daminozide Toth fed to test mice.

Bowing to the panel's recommendations for more research, Dr. John Moore, EPA's assistant administrator for pesticides and toxic substances, announced that the agency would delay a decision until Uniroyal completes its own studies in 1989.

Uniroyal has since tried to dispel doubts about its product. Chris Exton, marketing manager, has written growers and processors about company tests that suggest daminozide is safe. Moore, however, calls Exton's letters "grossly misleading." In June 1987 he asked Uniroyal to issue a clarifying letter, and the company complied.

Meanwhile, evidence against daminozide is mounting. A May 1987 National Academy of Sciences report calculated potential cancer risks from daminozide and other pesticide residues found in raw and processed food. The report criticizes EPA's handling of pesticide regulation and estimates that 8.3 people per thousand exposed to daminozide will get cancer.

In view of EPA's hesitation, the response of supermarkets and food processors is striking. In the summer of 1986, leading supermarket chains—including Safeway, Giant, Kroger, and A&P—decided to refuse daminozide-treated apples. After prompting from consumer advocates at Public Citizen and NRDC, processors such as Heinz, Gerber, Duffy-Mott's, and Tree Top followed suit. Heinz won't make baby foods or juices from crops treated with daminozide or at least 11 other chemicals that EPA classifies as possible health threats. Gerber allows growers to use chemicals under federal scrutiny only if no residue is detectable after processing.

Since the controversy erupted in 1985, daminozide sales have dropped as much as 75 percent, according to Uniroyal. Two years ago, more than a third of the U.S. apple crop was sprayed with the chemical. □

SARAH HENRY is a reporter at the non-profit Center for Investigative Reporting in San Francisco. Jane Thrall provided research assistance.

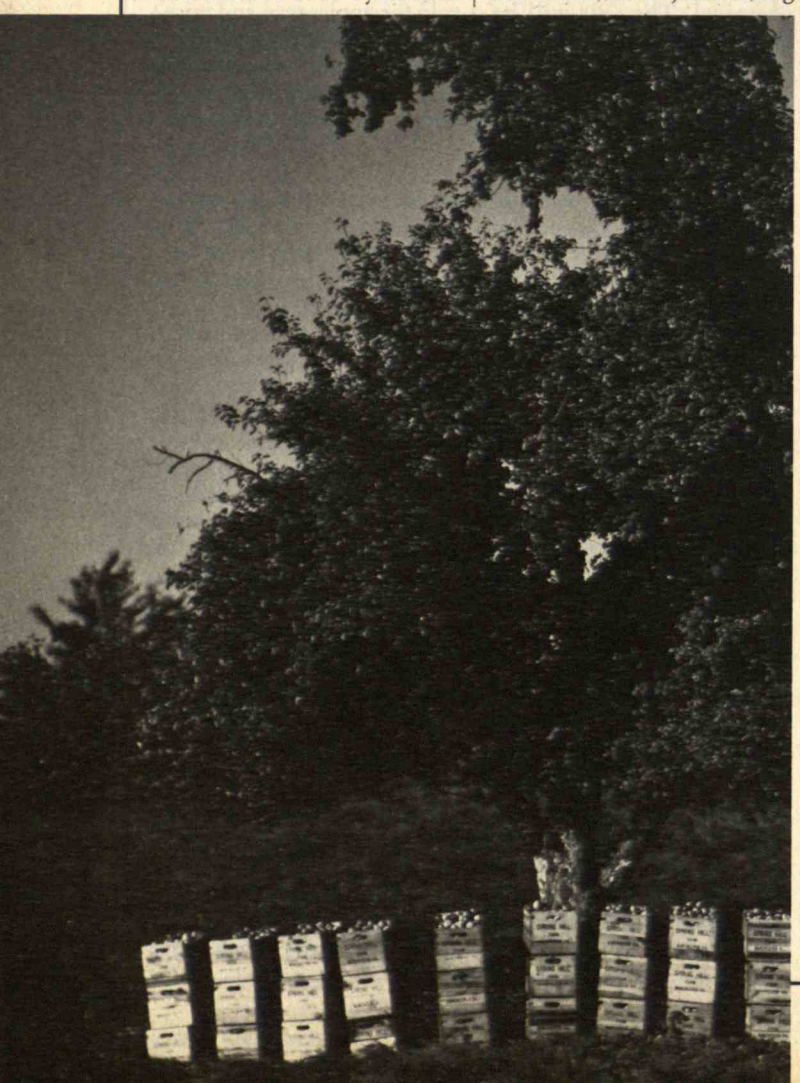


PHOTO: INTERNATIONAL APPLE INSTITUTE

Was Newton Wrong?

Isaac Newton may have overlooked an important part of the story when he attributed the apple's fall to gravity. Some physicists suspect that a previously unrecognized "fifth force" slowed the descent. The force would work over distances ranging from a few feet to a few thousand feet, and it would vary according to the material in an object.

"If it exists, it's an entirely new force," says Ephraim Fischbach, a Purdue University physicist whose revisionist study of gravity has generated much of the interest in the fifth force. Experimental evidence is inconclusive, but scientists on the trail of a fifth force are encouraged by hints of errors in the existing theory of gravity.

In 1687, Newton described the first force, gravity. The greater the mass of objects, the greater the attraction between them, regardless of the substances involved. Since then, scientists have identified three more forces: electromagnetism, which holds an atom's electrons in orbit around the nucleus; the "strong force," which binds the protons and neutrons of a nucleus together; and the "weak force," which causes atoms to decay.

Fischbach's fifth force would be repulsive. He believes it is 100 to 1,000 times weaker than gravity, and materials with more protons and neutrons might exhibit more of it. "It's going to depend on some combination of how many protons and neutrons and electrons are in the atom," he says. Thus, in a vacuum a block of iron would fall to earth more slowly than

The results of research in Greenland last summer could require revising the law of gravity.

aluminum of the same mass.

However, the fifth force would be so weak that it could easily be overlooked. "We've tacitly assumed we've been measuring gravity, but in fact it may be gravity and a fifth force," says Eric G. Adelberger, a University of Washington physicist.

A fifth force excites physicists because it could yield a long-sought goal—a single theory that would explain the four known forces. Without a fifth force, Fischbach believes, "It may be you have a puzzle with some of the pieces missing."

But there are many doubters. Among them is Sheldon Glashow, a Harvard University Nobel laureate who helped develop a theory uniting electromagnetism and the weak force. "There's not available evidence to think it exists," he says. "It's really only of interest to half a dozen scientists and the public that gets excited over press reports."

The experimental evidence thus far has been inconclusive at best. In 1981, Frank Stacey of the University of Queensland reported higher-than-expected gravity in an Australian mine shaft, suggesting the possible presence of another force. And Paul E. Boynton, Adelberger's colleague at the University of Washington, looked for a fifth force inside a horizontal shaft in the Cascade Mountains with a ring that is beryllium on one side and aluminum of equal mass on the other. Gravity attracted the aluminum half more strongly, a result "we cannot account for with conventional physics," says Boynton. In the relatively homogeneous materials in a mine, researchers can better identify the materials from which gravity might arise.

The search for a new force accelerated two years ago when Fischbach found anomalies in data from a classic turn-of-the-century experiment. The experiment by the Hungarian physicist Roland von Eotvos supported Newton's contention that gravity is independent of an object's composition.

However, even Boynton expects the explanation for the quirks to come from conventional physics. And when Adelberger measured the gravitational force on cylinders of beryllium and copper near a vertical glacial hillside that should have been massive enough to produce a recognizable fifth-force effect, he detected nothing unusual. He now plans to repeat his experiment at the site where Boynton detected a potential fifth-force.

Robert H. Dicke, a Princeton University physicist, says "it makes theoretical sense" that there could be a fifth force, but he notes that small variations in temperature might produce some test anomalies. Moreover, correcting for the effects of various materials in the mine and hillside experiments is very difficult.

Conclusive evidence could come with the results from an experiment conducted last summer in the Greenland ice caps. The experiment took some of the most sensitive measurements ever of the so-called Big G—a number relating gravity, mass, and distance that classical theory says should be constant everywhere.

The scientists measured gravity over distances at which the theoretical fifth force should be evident. "Big G was never measured on scales of thousands of kilometers—always at centimeters—and assumed to be the same," says Mark E. Ander, a geophysicist at Los Alamos National Laboratories and part of the Greenland team.

The team lowered equipment into a deep hole drilled in the ice cap and measured gravity at nine intervals over a 1,500-meter distance. Since the density of ice is well known, its effects on gravity should be easier to calculate than the effects of rocks in a mine, Ander says.

"We're questioning the validity of the law of gravity as it now stands," Ander points out. Fischbach believes that if the Greenland team revises Big G, "that's very significant. . . . That would in itself be evidence for a new force."

If the fifth force exists, says Fischbach, scientists would have to recalculate the mass of celestial bodies. He thinks each would be about 1 percent lighter. And he speculates that understanding a fifth force could lead to unforeseen technologies. He makes the analogy to nineteenth-century physicist James Maxwell's description of electricity and magnetism as a single phenomenon. That intellectual leap led to radio and television. □

DAVID GRAHAM is a Knight Science Journalism fellow at M.I.T.

Biotech Waste

Throw a handful of yeasts into a vat of grape juice and they'll make wine. Throw the right genetically engineered microorganisms (GEMS) into a vat of sugar, vitamins, and nutrients, and they'll produce insulin.

Like yeasts, these organisms are separated from the final product, sterilized—usually with steam—and laid to rest in a solid-waste landfill. However, a large batch of yeasts is no cinch to sterilize. Six to seven percent regularly escape death owing to shortcomings like inadequate stirring or heating.

No one worries about this margin for error with yeasts. But with GEMS, it could constitute what is called a deliberate release. Although genetic-engineering experiments in the environment are required to undergo a battery of tests and committee reviews to minimize the risk of such releases, GEMS in waste can escape undetected and unregulated.

"If the Environmental Protection Agency (EPA) is going to regulate deliberate releases of live GEMS on 10 acres of soil," says Margaret Mellon, a biotech expert at the National Wildlife Federation, "then they're going to look pretty foolish if someone finds out that truckloads of the stuff are being released out the back door as waste."

The inconsistency exists because biotech waste is not viewed as a product of the industry. If it were, it would be subject to regulations concerning deliberate release. Nor is it considered hazardous waste, which is covered by such laws as the Resource Conservation and Recovery Act, Superfund, and the Marine Protection, Research, and Sanctuaries Act. Instead,

PHOTO: CHARLES BARNETT

the material is seen as similar enough to conventional biological refuse to be governed by state and local regulations on disposing solid waste.

Members of the industry see no cause for alarm about occasional releases of GEMs in waste. "Granted, if you have an organism that is specifically designed to survive in the environment, there are legitimate questions that need to be asked before that organism is released," says John Keene, an institutional biosafety officer who chaired a panel on waste management for an American Society of Testing Materials meeting in October 1987. "But the organisms used in large-scale processing of pharmaceuticals are built not to survive in nature." Conditions outside the lab, he says, "are not right for them to grow."

Keene believes that companies use only organisms that won't survive if they get out. "Companies are not going to use non-enfeebled organisms that will cause them problems in terms of public perception of risk. It's not worth it."

Eliminating Uncertainty

Mellon argues, however, that community dissatisfaction isn't an effective deterrent. "The public can't see a microbe. It's not going to have a good idea of what's being released." She suggests that a federal agency should be responsible for watching what is released in waste.

For the present, biotech companies have voluntarily complied with the National Institutes of Health (NIH) Guidelines for Research Involving Recombinant DNA Molecules, which detail the laboratory and waste-disposal practices that government-funded projects must obey. As a rule, members of the industry have installed efficient containment and sterilization equipment to prevent GEMs from escaping.

However, the NIH isn't responsible for determining how effective the waste-treatment systems are. In an attempt to eliminate some of the uncertainty, EPA's Office of Solid Waste sent out a survey in September to 31 companies that handle GEMs in quantities over 100 liters. In addition to requesting a host of information about organisms, products, and disposal practices, the 23-page mandatory questionnaire calls for a detailed "process block flow diagram"—a flow chart of the manufacturing process for each biotech product, showing all points where substances are added and released.

"A lot of times companies fill out surveys incorrectly," says Jodi Bakst, the EPA administrator who originated the survey. "We study the process block flow diagram and see if it is consistent with the quantities the companies claim. That way, if a company tries to smooth out the numbers we'll catch it." And if these surveys turn up evidence that GEMs are being released? "The first thing the EPA will probably do," says Bakst, "is go out and start testing."

The survey is by no means comprehensive; the biotech industry extends well beyond these 31 companies, and many use GEMs in quantities of less than 100 liters. But when the analysis is complete, EPA should know if the industry as a whole or some segments pose a hazard. If a problem is found, the next—and more difficult—step will be deciding what to do about it. □

SHAWNA VOGEL is a contributing editor at Discover *magazine.*

Chesapeake Bay Cleanup

A body overloaded with food gets clogged arteries. Overload an estuary with nutrients and the water clouds up, fish die, and waterfowl and aquatic vegetation disappear. These symptoms signal a severe illness.

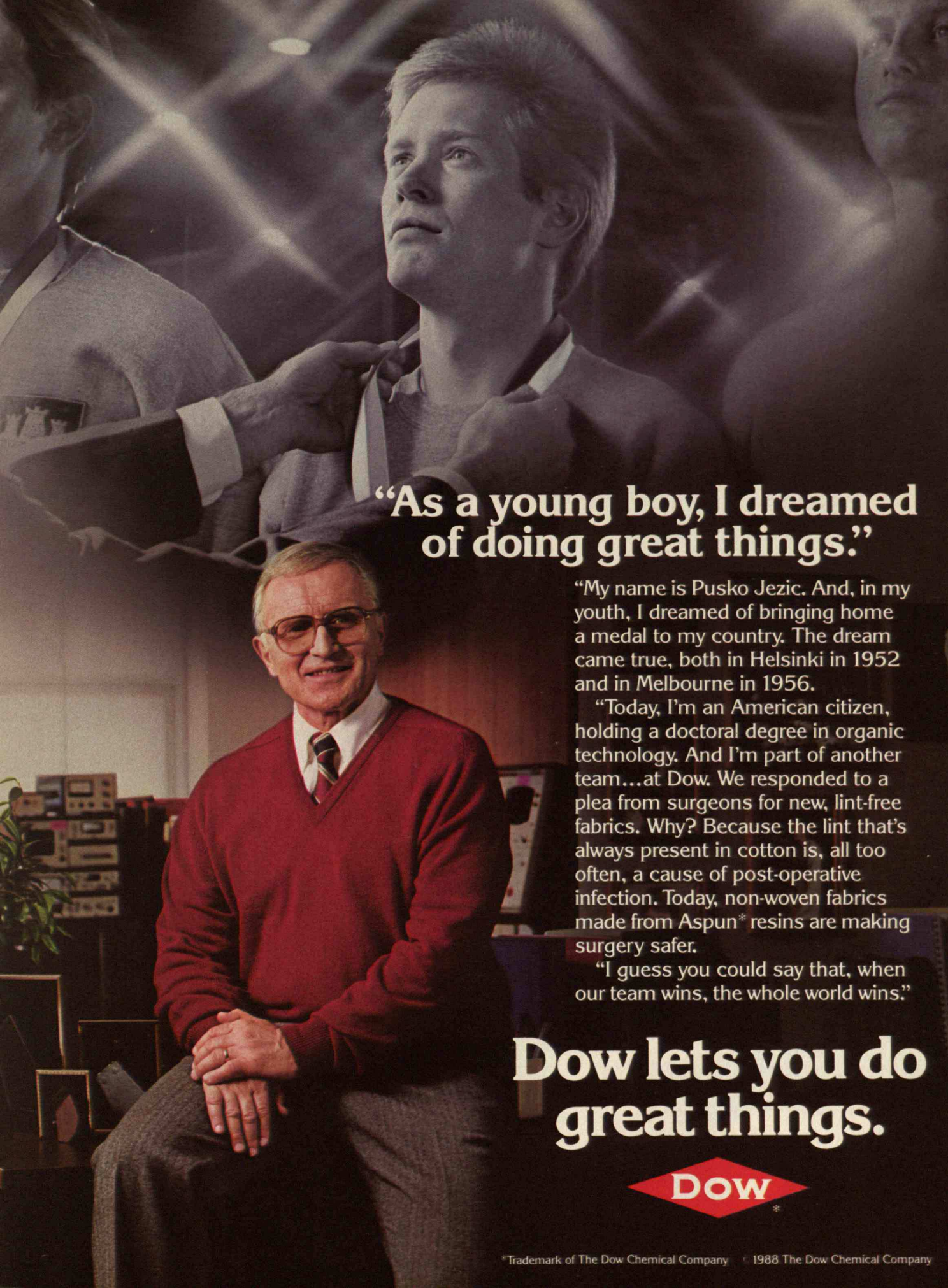
In the Chesapeake Bay, efforts are under way to control this illness, thanks to a cooperative agreement approved by officials from Virginia, Maryland, Pennsylvania, the District of Columbia, and the federal Environmental Protection Agency. Signed in 1983, the three-paragraph document is a model for protecting marine systems that cross political boundaries. Its success led to an even more extensive agreement in 1987.

One of the first and most alarming signs of the Chesapeake's illness came in the 1970s, when scientists and others noticed that "submerged aquatic vegetation" was disappearing. Such vegetation provides food for waterfowl and a habitat for spawning fish and shellfish. Excess nutrients like phosphorus and nitrogen had caused surface algae to grow so much that they blocked sunlight and killed bottom grasses.

Since 1983, the trend has slowed. According to Robert Orth at the Virginia Institute of Marine Science (VIMS) at Gloucester, the average acreage of underwater vegetation has changed little in recent years—except for an unexplained but welcome 26 percent increase from 1984 to 1985.

Protecting underwater vegetation primarily requires limiting the nutrients that

ILLUSTRATION: JON McINTOSH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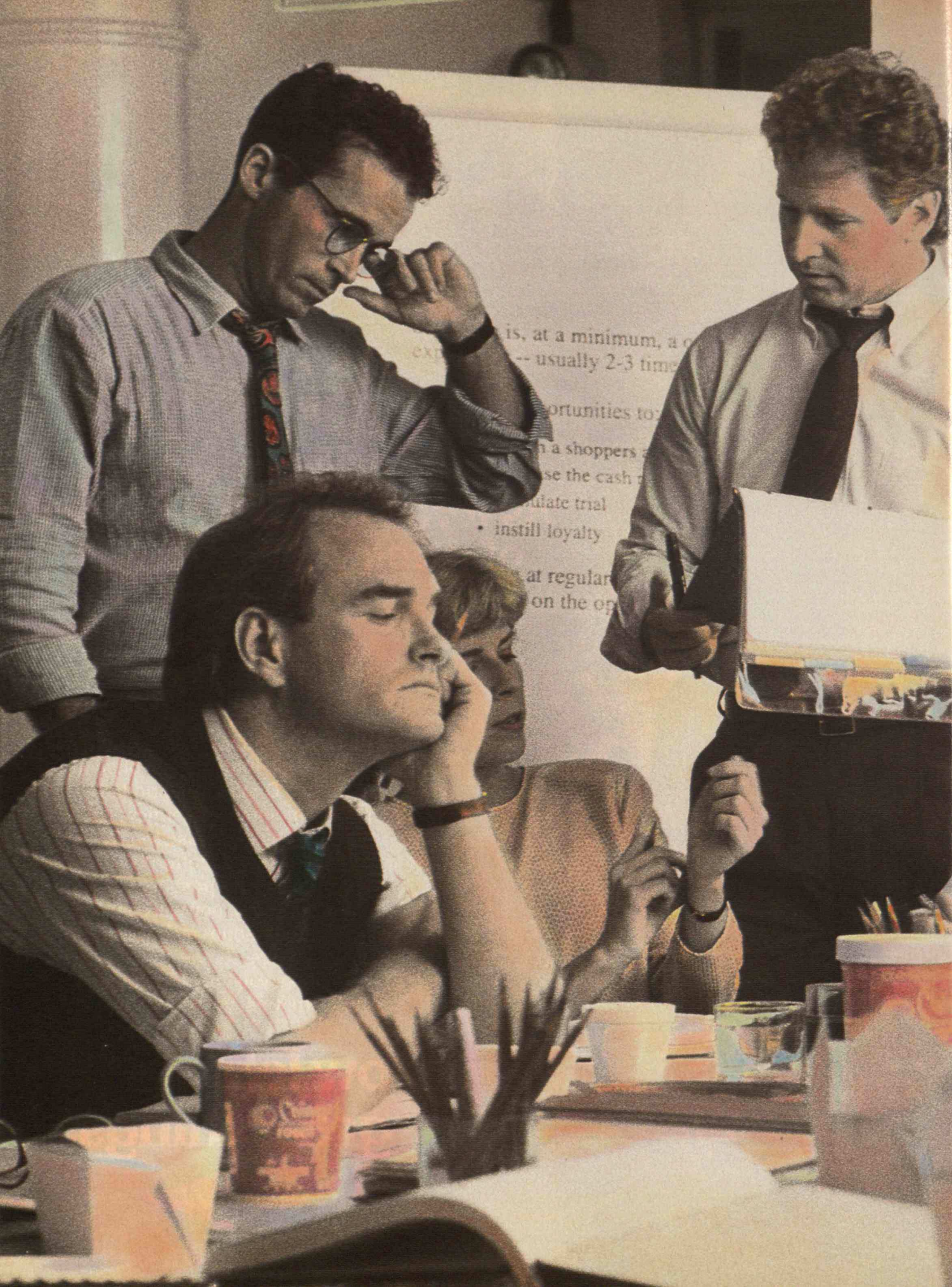
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An agreement that crosses political boundaries is helping protect the Chesapeake Bay from pollution threats.

feed surface algae. These nutrients come from two types of sources. "Non-point" sources include farms, lawns, parking lots, and other land areas from which water drains. "Point" sources include more than 2,750 wastewater treatment plants. Although some plants have been modified to reduce phosphorus discharges, most government jurisdictions have balked at building costly facilities to extract nitrogen from waste water.

Advances have been made in limiting both types of sources. Last year, Hampton Roads Sanitation in Virginia Beach set up two pilot projects to test biological ways to remove nitrogen. Most nitrogen in waste water exists as ammonia, so about two-thirds can be removed by mixing the water with air. This stimulates the natural ability of bacteria to convert ammonia to nitrogen gas that can be released harmlessly into the atmosphere. The biological approach is up to 30 percent cheaper than current chemical methods.

To curb pollution from non-point sources, states have sponsored cost-sharing, research, and education programs that promote "best management practices" (BMPs). A project headed by Saied Mostaghimi at Virginia Polytechnic Institute has shown the success of a BMP called no-till planting in which seeds are sewn through a slit drilled in the soil; this leaves dead plant material as a surface mulch. The method can cut runoff during a downpour in half, significantly reducing sediment, phosphorus, and nitrogen loss.

In Virginia, 1,444 farmers have adopted BMPs as a result of state programs. The Chesapeake Executive Council notes that 58,594 Virginia acres have been converted to BMP, saving 333,930 tons of sediment and reducing the phosphorus soil particles carry by 33,760 pounds. A BMP called wet ponds, used in Virginia's Fairfax County removes up to 87 percent of the silt and 80 percent of the phosphorus runoff from streets.

Limiting Future Threats

In addition to controlling nutrients, the bay agreement singles out wetlands for protection and restoration. Wetlands filter runoff and stabilize shorelines by subduing waves and slowing erosion.

Until recently wetlands were usually considered nonproductive, and hundreds of thousands of acres were lost to development. Now Maryland's legislature has stringent safeguards for wetlands. In most cases, the Critical Areas Law limits housing in a 1,000-foot-wide buffer around undeveloped areas to one unit per twenty acres.

The 1987 initiative introduces specific and measurable cooperative goals. Moreover, identifying and controlling toxic discharges is now a key objective. Though the excess of nutrients is seen as the biggest threat to the bay's health, toxic chemicals and metals are appearing in small quantities in animals and plants. Currently, the bay's toxic hot spots are at the Elizabeth River in Norfolk, Va., and Baltimore Harbor, both heavily industrialized areas with shipping and naval installations.

Some observers say even more needs to be done. For example, the 1987 agreement doesn't indicate how its targets are to be reached, nor does it specify goals for limiting toxic discharges. The Chesapeake Bay Foundation, the largest private environmental group devoted to the bay, has urged legislators to add mandatory programs, more exact timetables, and measures that cross state boundaries.

Two recent projects illustrate new potential threats to the bay. A proposed 400-acre island was to house a sports facility in the James River off Newport News, Va. The plan was dropped after a VIMS study indicated that the island would interfere with oyster larvae.

A second plan is still alive. The navy wants to test the ability of electronic weapons and communications systems to withstand the electromagnetic pulse (EMP) generated by a nuclear explosion. Research at VIMS suggests that EMP alters magnetite, a substance in turtles' brains that plays a role in navigation.

Still, observers agree that the Chesapeake Bay cleanup is a major step forward. The knowledge of the estuary that has accumulated since 1983 can be applied to areas just now showing stress, including the Puget, Albemarle, and Pamlico sounds. For instance, VIMS is one of the few organizations in the world that has experimented with underwater seeding to increase vegetation.

VIMS scientists harvest reproductive shoots from marsh eelgrass and drop them into tanks. Here seeds separate from the shoots, settle to the bottom, and are collected. A unique underwater device sows the seeds in damaged areas on the bottom of the Chesapeake estuary. Since this method requires much less labor than transplanting shoots, it holds great promise. □

SUSAN A. MOTLEY is a freelance writer specializing in environmental issues.

PHOTO: CHESAPEAKE BAY FOUNDATION, INC.; RODNEY A. COGGIN

MINI • TRENDS

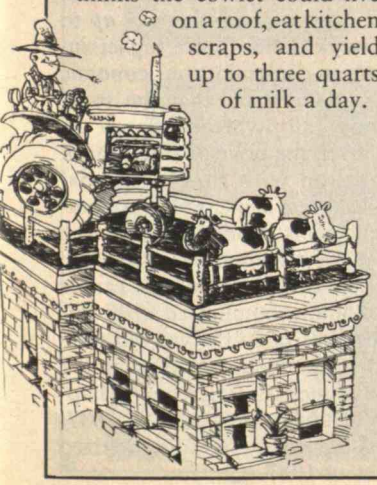
TECHNO-PROTECTIONISM

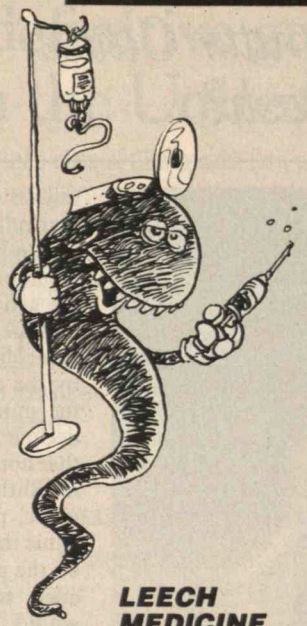
Israel and Japan are leaders in artificial-intelligence research. West Germany and Hungary are among the top nations in new manufacturing systems. Denmark and the Soviet Union are big on new cements. And more than 60 percent of engineering and technology research publications originate outside the United States.

Viewing this increasing engineering activity abroad, a National Academy of Engineering (NAE) report proposes that academic, government, and industrial programs in this country be modified. "Technological protectionism is not a sustainable path as a general course," cautions the NAE report. It also suggests that U.S. technologists need access to significantly more foreign research. According to NAE president Robert M. White, "There is a growing appreciation that in today's world, a company or a nation must be cooperative to be competitive."

CITY COWS

José Manuel Berruccos Villalobos at the National University of Mexico has bred a two-foot-tall "microcow," reports *Leaders* magazine. He thinks the cowlet could live on a roof, eat kitchen scraps, and yield up to three quarts of milk a day.





LEECH MEDICINE

They're ugly little suckers, but after more than a century of neglect, leeches are wriggling back into medicine. They saved the fingertip of seven-year-old Donnel McLucas of St. Louis, Mo. An accident had cut it so close that surgeon Bruce A. Kraemer of the Washington University School of Medicine could find no veins in it to reattach to veins in the rest of the finger.

Kraemer restored blood flow to the tip by sewing arteries back together, but blood could not circulate back out. It accumulated and made the tip blue and swollen. The solution: *Hirudo medicinalis,* the medicinal leech. About once every eight hours, Kraemer placed one of these bloodsucking relatives of the earthworm on Donnel's fingertip. The swelling went down and the tip regained a healthy color. Two weeks and 25 leeches later, the boy's fingertip could drain itself.

Kraemer calls leeches "incredibly wonderful creatures .... They dig a little hole; they inject anesthetic into it; they put in an anti-coagulant so it keeps bleeding; and they put a vasodilator in, which helps dilate all the little blood vessels that flow into the area."

VERY BIG

Brent Tully of the University of Hawaii's Institute for Astronomy thinks the Milky Way might be part of a flat, oblong "supercluster complex" 100 times more massive than any previously known entity. The Pisces-Cetus Supercluster Complex, named after the constellations in which it is seen, includes millions of galaxies and extends across a tenth of the observable universe. It is about 1 billion light-years long and 150 million light-years across.

Tully has analyzed a large body of data on the position of rich clusters and used a supercomputer to map them. The evidence suggests that galaxies are not randomly distributed, but are instead grouped together in a way not anticipated by conventional theories of galaxy formation. Tully concludes that about 60 rich clusters are concentrated in the Pisces-Cetus complex.

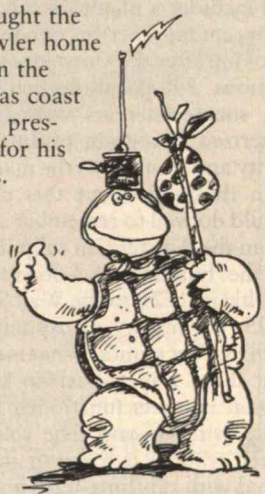
AH, WILDERNESS!

Pictures of green fields and other calming images may soften the harsh interiors of future spacecraft, easing the tedium of long-term heavenly journeys, says Richard Coss, a psychologist at the University of California at Davis.

He has studied the reactions of more than 300 subjects to a variety of pictures and found that the most preferred pictures are those with great depth of field such as landscapes. "What we found was that people like to look outside," Coss says. "It's the kind of thing you'd find in a modestly priced motel room."

TURTLE STEW

Scientists are placing tiny radio transmitters on sea, land, and air animals and using satellites to track migration patterns. These experiments are yielding important scientific data, but they are also giving researchers a few surprises. According to *National Wildlife,* one scientist found a sea turtle transmitting from landlocked Kansas. It seems a farmer had brought the crawler home from the Texas coast as a present for his kids.



FRESH WATER

Engineers from Argonne National Laboratory and the Solar Energy Research Institute recently produced six gallons of drinking water while generating electricity through ocean thermal energy conversion (OTEC). The project demonstrated that the steaming seawater driving generators in power stations can be condensed to yield fresh water. The technique cools the steam with cold water pumped through pipes that extend half a mile below the ocean's surface.

According to Anthony Thomas of Argonne, a working OTEC plant would use about 50,000 gallons of water a minute for every megawatt of electricity produced. About 500 gallons would be converted into fresh water, and the rest would be returned to the ocean. "This means that in addition to providing electricity, future OTEC plants could provide fresh water to islands and coastal cities."

ILLUSTRATIONS: JON McINTOSH

LESTER C. THUROW

Did the Computer Cause the Crash?

THE fall of the stock market last October has revived an all-purpose lament that seems to be trotted out whenever any of the myriad glitches of modern life occur. What do you blame when your airplane reservation inadvertently gets cancelled or when your phone bill includes a phantom call to Tashkent? Why, computer error, of course. Likewise, not long after the Dow-Jones posted a precipitous 508-point decline last October 19, some observers were blaming computerized "program trading" for the severity and rapidity of the market's decline.

In thinking about this claim, readers would do well to remember a little history. From the Amsterdam tulip mania of 1637 to the bursting of London's South Sea Bubble in 1720 to the Wall Street crash of 1929, the history of capitalism is replete with market panics. What is unusual is not that there was a crash in 1987 but that capital markets functioned for nearly 60 years without one. The role of computerized trading is a minor influence compared with this long-term historical trend.

There are two kinds of program trading, stock-index arbitrage and portfolio insurance. The first depends on discrepancies between the current prices of stocks on the New York Stock Exchange and prices on stock futures—contracts to buy a stock at a certain future date—traded in Chicago. In stock-index arbitrage, a computer program monitors the differential in price between the Standard & Poor's 500-stock index and the "futures index" of the same stocks. The system is programmed so that whenever the differential reaches a certain point, the computer automatically issues orders to buy and sell.

For example, if the price of the futures index is significantly below that of the Standard & Poor's index, then the program will sell stocks and buy futures. In effect, the computer functions just like a human arbitrageur, making money off the gap between the two markets and narrowing the differential in the process.

As the name implies, portfolio insurance is a technique to protect large insitutional investors from losses on the stock market.

ECONOMIST LESTER C. THUROW IS DEAN OF THE SLOAN SCHOOL OF MANAGEMENT AT M.I.T.

Don't blame technology for the mania of the market.

The computer is programmed so that, as stock prices drop, at regular intervals the system sells index futures—contracts to deliver stocks at a later date and at a given price. The price is usually close to the present market value of the stocks. That way, even if the market drops further, the investor will be able to get the agreed-on price of the stocks, rather than the new, lower price. This protects the investor from excessive losses.

Computers make program trading possible because they can monitor more information faster and give the appropriate buy or sell orders long before a human could figure out what to do. However, the techniques of program trading and the software used to practice them are very much human creations. Like all expert systems, they merely mimic the actions of a human expert, in this case a broker. The computer can only respond to events that have already happened and act according to the rules built in to the program by the broker. Thus, to blame the market's rapid fall on the fact that computers are automatically executing decisions that brokers would have made anyway is to make the common mistake of blaming the tool for the actions of the people using it.

If the computer did not cause the crash, what did? It depends on what you mean by the question. If by "cause" you mean the immediate catalyst of the 508-point decline on October 19th, the answer is that nothing or no one in particular caused it. Rather, it was the product of herd panic, not so different from the sudden panic that occurs among herds of antelope on the plains of Africa. To know why the crash took place precisely when it did would require understanding herd psychology, and even the best animal behavior experts don't pretend to know why antelopes (or humans) panic precisely when they do.

However if by "cause" you mean the reason why stock market values had to decline sooner or later, then there is a simple answer. In mid-October interest rates were around 10 percent. This created a price-to-earnings ratio on bonds of ten to one. For every ten dollars of investment in bonds, an individual earned one dollar of interest. At the same time the price-to-earnings ratio in the stock market was twenty to one. In other words, it took twenty dollars to earn on the stock market what it took only ten to earn on the bond market—a clear sign of how overvalued most stocks were.

It makes absolutely no sense to keep buying stocks in such a situation—unless, of course, you think that interst rates are about to come down (lowering earnings on bonds) or that equity earnings on the stock market are about to boom. But last fall, interest rates were on the way *up* to defend the weak dollar. Since higher interest rates mean constraints on economic growth, it was inevitable that the stock market would fall (whether slowly or quickly) to bring the price of stocks back into equilibrium with that of bonds. Whether stocks were being traded by computers or humans is beside the point.

As to how the two markets were able to get so far out of line without an earlier correction, that is a complicated story. Put simply, it depends upon the age-old willingness to suspend one's critical judgment when lots of money is being made. It happened in the Dutch tulip mania of 1637. It happened again in the computerized stock market of 1987. □

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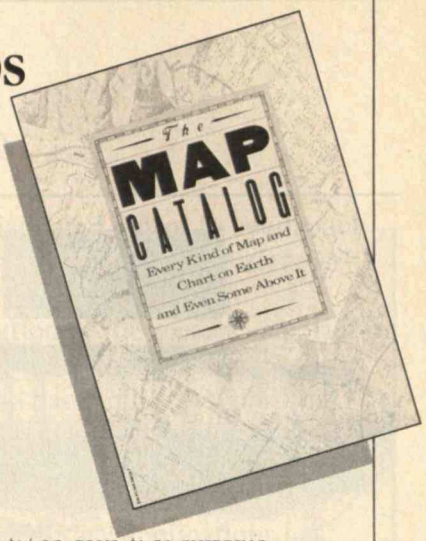

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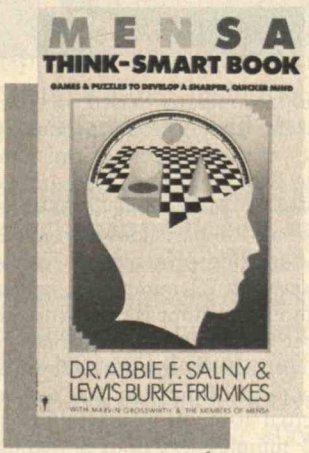

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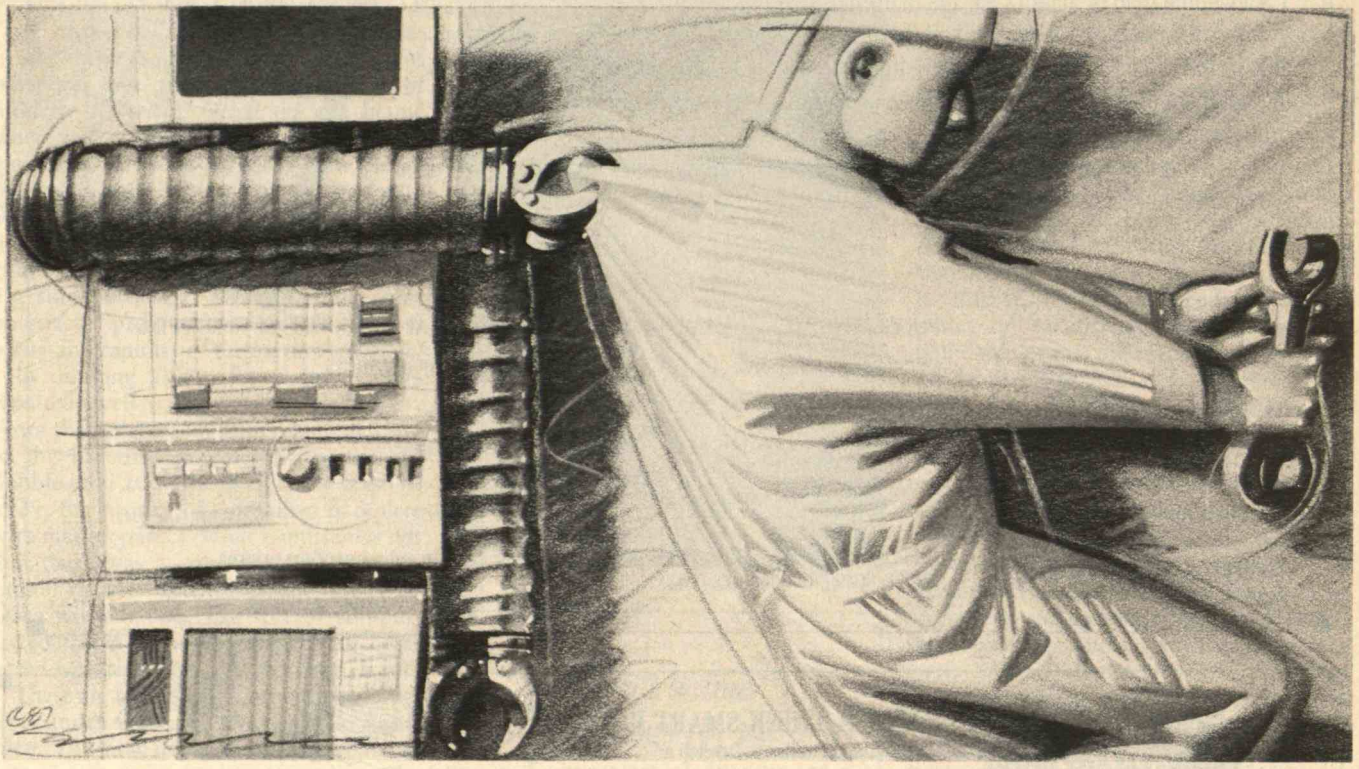
BY TIM WARNER

Computers as a Competitive Burden



At a cost of many millions of dollars, a major Canadian electronics manufacturer established an automated warehouse for incoming components. Robots glided up and down the high-rise bays, selecting bins of parts and passing them to a conveyor system. Bar-code scanners identified each bin and routed it to a stock picker, who removed the items and sent them via an automated vehicle to the factory.

The system—the epitome of the ballyhooed "factory of the future"—is now idle. The company's suppliers deliver most of the needed parts directly to the factory, bypassing the automated warehouse.

The company's managers apparently thought that the computer-based technology was the way to reduce manufacturing costs. But then they recognized that their operations would work better without computers.

Too many companies look to information technology—here a rubric for the many computerized devices used in manufacturing—as the sole key to competitiveness. Most companies would do better by simplifying their products and production systems and so removing the conditions that require computers. Only after restructuring their operations can companies assess the proper role of computers in production.

Too often computer fixes divert manufacturers from improving the efficiency of our industrial base.

Fewer Parts, Less Labor

Why aren't computerized systems typically the best offense against inefficiency? A few examples provide the answer. Northern Telecom—a major telecommunications company based in Canada—faced the challenge of producing telephones at the low cost of those made in Pacific Rim countries. The company responded by redesigning its telephone so that it had 156 parts, down from 325, and by automating production. The original handset took 23 minutes to assemble. If the amount of labor is proportional to the number of parts, then workers should have been able to assemble the redesigned product in 11 minutes. After automation, the actual assembly time was 9 minutes—just 2 minutes less than if manual production had continued. Clearly Northern Telecom achieved its major leverage by simplifying its product.

The manufacture of the IBM Proprinter is another case in point. Engineers designed the printer with only 60 parts compared with a competitor's 150—a 60 percent reduction. And Ford Motor Co. reduced the number of pieces in the sidepanel of its Taurus automobile from 15 to 2. These products are easier to manufacture and more uniform in quality than their more complicated counterparts.

It also makes sense to redesign basic production systems before assigning com-

Continued on page 24

TIM WARNER is assistant professor of administrative studies at York University in Toronto. *A version of this article appeared in the fall 1987 issue of* Sloan Management Review.

ILLUSTRATION: SALLY COMPORT

A spacecraft to be sent to explore Earth's planetary twin will use a sophisticated sensor to beam back the first detailed map of Venus. NASA's Magellan Mission will carry a synthetic aperture radar (SAR) and an altimeter antenna to peer below Venus' dense, noxious carbon dioxide/sulfuric acid atmosphere. The sensor, built by Hughes Aircraft Company, has a resolution of 100 meters, superior by a factor of 10 over the resolution of current surface data. During a projected eight-month period, the spacecraft will map over 90 percent of the Venusian surface, sending data back to Earth regarding geological processes that formed the planet. The Magellan Mission is scheduled for launch aboard the Space Shuttle in April 1989.

A system for night reconnaissance, border surveillance, and specialized military applications has recently completed 150 successful cross-country demonstration flights. The approach utilizes a Hughes Night Vision System (HNVS) aboard Schweizer Aircraft Corporation's new SA 2-37A Special Purpose Aircraft. The HNVS is a forward-looking infrared (FLIR) system that lets crew members see at night and in poor visibility conditions. Unlike radar, the FLIR emits no energy of its own that can be detected during operations. It can locate and track vehicles and, at its maximum magnification setting, can even delineate individual tree limbs and branches. HNVS is in use by the U.S. Army and the U.S. Customs Service, and was selected for use on the proposed V-22 Osprey tilt-rotor aircraft.

A new graphics projector offers improved performance for the large-screen display of computer data. Designed and built by Hughes, the Model 800 graphics projector increases brightness to more than 600 lumens and improves resolution to over 1,000 lines edge to edge. The projector combines high-intensity illumination with Hughes' liquid crystal light valve technology to generate bright, real-time projected displays of both graphic and alphanumeric images in normal room light. The Model 800 is designed for applications including computer-assisted training, design conferences, sales presentations, teleconferencing, and classroom and lecture hall use.

The highest resolution ever obtained for scanning ion microscopy, representing a two-fold reduction in probe size, has been demonstrated by Hughes. Using a focused ion beam microprobe, features assmall as 15 nanometers—approximately 100 diameters of an atom—have been clearly resolved in images of nickel crystals in a wire mesh. This size resolution increases the utility of this technology for high-resolution chemical analysis of surfaces and as a microfabrication technique. Such ultra-high resolution may permit the fabrication of the smallest microelectronic structures ever made—structures in which electron movement is confined as never before, and in which new properties of quantum physics take effect.

Hughes Missile Systems Group is advancing every phase of research and development, as it applies to tactical guided missile systems and strategic defense. Opportunities for engineers and scientists are in analog/digital circuit design; high-voltage power supply design; transmitter and radome design; electro-optical design; IR imaging sensors; focal plane arrays; mechanical engineering and systems engineering. Send resume to Hughes Engineering Employment, Dept. S4, 8433 Fallbrook Ave., Canoga Park, CA 91304. Equal opportunity employer. U.S. citizenship required.

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CONTINUED FROM PAGE 22

puters to complicated situations. Two sensible methods for streamlining work flow are now in vogue—"manufacturing cells" and "just-in-time" ordering. Yet all too often North American corporations try these ideas only after they have turned to computers for coping with their production lines.

Consider the typical reaction to the severe scheduling problems that most parts makers face. The typical machined part spends 95 percent of its time waiting to be cut. A machine tool may spend the bulk of its day waiting for work or being set up. The waste of resources has motivated the increasing use of computerized job-shop scheduling systems. But these tools often make complex systems more complicated because they add more components that can also develop problems.

The Russians, Europeans, and Japanese have evolved a much simpler system based on the concept of classifying parts in terms of similar fabrication sequence, shape, and size. Suppose a job shop can allocate 80 percent of its volume to families of like parts. Then the shop can process each family through a "manufacturing cell" in which the needed machines are placed in the correct sequence. This technique, known as group technology, dramatically reduces scheduling problems and costs much less than adding computers. At the General Dynamics plant in Pomona, Calif., group technology has reduced production time by 55 percent. In some instances jobs that previously traveled a total of two and a half miles from machine to machine now travel less than 200 feet.

For the factory floor, many manufacturing companies have set up automated "material requirements planning" (MRP) systems to avoid costly inventories. An MRP computer program forecasts a factory's production schedule and then determines when components will be needed, building in lead times for their manufacture and delivery.

But MRP systems are notoriously difficult to implement, consume substantial computer power, and require the labor of programmers and the like. Furthermore, MRP programs actually build in inefficiencies. For example, they typically assume that parts have to spend time waiting on the shop floor. And to allow for uncertainties in production, the systems often inflate the need for parts. Moreover, MRP systems do not motivate the work force to become more efficient. When workers find that the supplies they need aren't there, they simply blame problems on the computer rather than on an individual who could correct the situation.

Contrast this system with the benefits of the "just-in-time" approach. Just-in-time relies on having suppliers nearby, and calls for placing the successive stages of a production system as physically close as possible. When one operation needs more parts, the predecessor receives a signal to produce more units. Batch sizes are small, so supplies are replenished quickly. The system is highly responsive and uncluttered with work-in-process, and it requires no elaborate materials-handling or inventory-control systems.

I do not intend to give the impression that non-computerized systems are universally better than automated methods for improving work flow. Computers can play a role in both just-in-time systems and manufacturing cells. Companies using the just-in-time approach can rely on microcomputers to send messages to their suppliers. Firms with manufacturing cells may also install computers to help them sort parts into families. But in these cases, computerization is not preceding other attempts to simplify production.

Sometimes blending more conventional streamlining techniques with computerization is appropriate. Long lead times for producing parts or uncertain reject rates favor MRP systems, so the factory does not need to wait weeks for components. But an approach based only on information technology considers these conditions immutable, whereas often they are not.

Once a firm has exhausted conventional approaches, it can examine the benefits of advanced computerization. Indeed, some of the finest examples of manufacturing efficiency incorporate state-of-the-art factory automation. Japanese manufacturers have adopted more robots and other programmable machines than their North American counterparts. The Japanese, having paid more attention to basics in their production systems, can better evaluate and use these technologies.

The issue is one of timing. A naive faith in technological silver bullets too often diverts North American manufacturers from the first step—the hard work of rebuilding the industrial base. This attitude is tempting them into costly, high-risk experiments. Only after companies take the hard road of improving their products and production systems through simple methods will information technology play a key role in improving competitiveness. □

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Several Asian countries have used Green Revolution techniques to greatly increase rice production, but the poor often still go hungry.

BY MICHAEL J. DOVER AND LEE M. TALBOT

FEEDING THE EARTH

AN AGROECOLOGICAL SOLUTION

THE U.N. Food and Agriculture Organization (FAO) paints a dismal picture of Third World hunger over the next two decades if massive increases in agricultural production (and stringent population control) are not achieved. FAO projects that if present farming practices continue, 64 countries—29 of them in Africa—will be unable to meet their populations' food needs by the turn of the century, even if all cultivable land is farmed. Rampant poverty and starvation will continue even as the West struggles to deal with a food glut because the poorest nations simply cannot afford to buy this food. Indeed, famine was more widespread in 1985 than in 1975.

In a drive to become self-sufficient and spur economic growth, many Third World nations have encouraged their people to adopt the capital-intensive agriculture of developed nations. And some poor nations have in fact increased their food production in what has come to be known as the Green Revolution. Yet even in these countries the poor are not necessarily less poor or better fed. For example in the Philippines between 1975 and 1978, wealthy urbanites increased their calorie intake by over 10 percent while their rural counterparts saw only a 2 percent rise in calories consumed. Even if food production outpaces population growth, there is no guarantee that starvation will subside.

Poor nations, and their farmers, also often cannot afford the industrial resources they need to emulate the agriculture of the West. And techniques of the developed world often do not work on the farmlands of the tropics, whose climate and ecology differ markedly from those of the temperate zones. Worse, misapplied industrial methods can destroy those fragile croplands.

To feed the world's poorest people, a new ag-

As Third World starvation persists, scientists hope to increase local food production by combining peasant farm technologies with modern savvy.

PHOTOGRAPH: DALE BOTTREAU

riculture must be created that is both ecologically sound and affordable by farmers working the most marginal tropical lands. Some scientists are devising just such a system by combining traditional farming methods, formerly scorned as "primitive," with the advances of modern biology and technology. Researchers hope that a new respect for the risk-reducing, resource-conserving older ways, wedded with knowledge of when and how to apply industrial techniques, could provide a more stable and productive world food future.

Unique climatic conditions make tropical soils poor candidates for industrial fertilizers.

Tropical Dilemmas

The tropics differ from the temperate world in the sheer variability of their climate. They encompass deserts, semi-arid areas, and regions with the world's highest rainfall. About half these areas have pronounced wet and dry seasons, so that some receive both too much and too little rainfall in the same year. Much tropical rain, moreover, falls in storms: 10 to 15 percent of the total number of rainy days contribute fully half the annual rainfall. This means that most ecosystems cannot make full use of the water when it comes. In many tropical agricultural areas, including large cropland areas of Africa and India, water shortages are comparable to those of temperate-zone deserts.

Yearly rainfall can also vary tremendously in the tropics. In much of northern and sub-Saharan Africa, the Arabian Peninsula, and Western India, a given year's rainfall can fluctuate more than 40 percent above or below the annual average. Needless to say, such fluctuations can dramatically affect food production. In certain parts of Africa, drought can cut yields in half if sowing is delayed as little as two weeks.

The continuously high temperatures of the tropics would seem to provide an advantage over temperate climates. Yet although photosynthesis increases with temperature, so does respiration, which consumes the food the plant has produced. In cereals grown in the tropics, respiration occurs at about 35 percent of the photosynthetic rate, compared with 25 percent in temperate climates. And much less solar radiation is available to crops in the tropics than in temperate areas, both because tropical summer days are over two hours shorter and because cloud cover is widespread during the tropical rainy season. Furthermore, because tropical temperatures are always high, evaporation rates are high, too. In semi-arid and arid lands, long sunny periods are advantageous only in irrigated areas.

These climatic conditions make tropical soils unique in their structure and fertility—and often poor candidates for conventional temperate-zone fertilizers. About 51 percent of these soils are heavily eroded and their mineral nutrients leach out readily. Many tropical forests have therefore evolved into ecosystems that maintain most of their nutrients above ground: as much as 90 percent of these elements may reside in trees, shrubs, and other plants. In these incredibly lush habitats, the soil itself can be virtually sterile. By comparison, as little as 3 percent of the nutrients in temperate-zone forests are stored above ground. Cut down a temperate-zone forest and 97 percent of the nutrients available for new growth will remain in the soil. Cut down a tropical forest and almost all of these nutrients will be hauled away in the timber. Thus it often doesn't pay to clear large forest tracts for farming. Yet it may be from just such land that the poorest farmers must try to eke out their livelihoods.

Havocs of Shifting Cultivation

Just as natural ecosystems have evolved to thrive under unique conditions, traditional farmers have developed an agriculture that allows them to survive

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on such marginal lands. Chief among the indigenous cropping systems is a technique called "shifting agriculture," "shifting cultivation," or "swidden." This practice, common throughout the tropics, involves cutting and (usually) burning patches of forest to clear land for crops. Swidden fields are typically used for one to three years before being abandoned by farmers who move on to clear other plots. Burning releases the reservoir of nutrients in the plant material (though much of the nitrogen goes up in smoke), making the soil-ash mixture relatively fertile. Burning also kills most weeds.

Some 6 million hectares of cropland are reduced to desert-like conditions each year.

Once abandoned, plots are left fallow for several years. The exact length of time depends on factors such as the availability of other land and the rate of forest regrowth. In general, the longer the fallow period, the more fertile the land when it's next cleared for crops. In Belize, Central America, for instance, even decade-long fallows are too brief to restore lost phosphorus to the soil using traditional methods. Many farmers with plots idled for 5 to 15 years report crop failures, with plants showing symptoms of phosphorus deficiency. In India, rice and maize yields on lands fallowed 5 to 10 years were found to be 98 percent and 48 percent lower than yields from plots cleared after a 30-year fallow.

About half the world's yearly loss of 12 to 21 million hectares of tropical forests results from mismanaged shifting cultivation. (One hectare equals about 2.5 acres.) For example, some 38 percent of the Philippines was forested in 1976, down from 75 percent at the end of World War II. The current rate of conversion to agricultural use has been estimated at 50,000 hectares per year. On the Philippine island of Negros, the number of farmers practicing shifting cultivation increased by 80 percent in just two years. Researchers predict that one major rain forest there will vanish completely by the turn of the century.

If the population of shifting cultivators in tropical forests stays low, the practice poses relatively little threat to forest survival. But because of overall population increases as well as the displacement of tenant farmers, the number of people trying to make a living this way has increased. This means that fallow periods have been shortened and the spaces between plots reduced or eliminated. Thus the forest cannot grow back in many parts of the tropics. In some areas forests have been replaced with permanent grassland, often dominated by one or two species. Indonesia has some 12 to 15 million hectares of such land, while the Philippines has about 5 million. According to Filipino ecologist Percy Sajise, the frequent fires that sweep these grasslands prevent regrowth of the forest and increase soil erosion. Grass, moreover, is much less efficient than forests in storing water and nutrients. Thus grass actually reduces soil fertility and exacerbates summer droughts and rainy-season floods.

Deforestation also contributes heavily to soil erosion. Erosion rates have increased 200-fold to 5,000-fold when African forest land has been cleared. The U.N. Environment Programme (UNEP) estimates that some 6 million hectares of cropland are being reduced to desert-like conditions every year, with an additional 14 million made entirely unproductive. Soil erosion in Africa and South America is proceeding at an annual rate of about 7 tons per hectare, compared with only 0.8 tons per hectare in Europe. Overall, according to Mostafa Tolba, UNEP's executive director, world agriculture will see a net loss of about 55 million hectares of agricultural land by the year 2000, chiefly because of erosion and the desertification that follows in dry areas.

Forest clearing also typically increases nutrient runoff, especially in hilly regions. Nutrient levels in runoff water at one U.S. study site increased from two to eight times when trees were removed. When these nutrients end up in lakes, they hasten algae growth (a process known as eutrophication), often making the water unsuitable for fish and human consumption. In the Philippines, deforestation has been implicated in this process, threatening local supplies of both fish and drinking water.

Shifting cultivators are not solely responsible for tropical deforestation. The pressing need for firewood in many parts of the world is another major cause, as is increased commercial logging and the

Draft animals serve many functions for Thai rice farmers, such as providing dung for fertilizer. When tractors replace animals—as in Sri Lanka—serious ecological problems can result.

conversion of forest to commercial pasture to produce meat for export markets. Still, agricultural technologies that promote conservation of rainforests would unquestionably help farmers produce more food on a long-term basis.

Industrial Abuses

Under the right conditions, industrial agriculture has dramatically increased Third World food production. Yet this technology can be applied only in certain areas. In Southeast Asia, for example, the "core areas" devoted to intensive Green Revolution food production account for less than 5 percent of the total land area. These regions invariably contain the best soils and are owned by people who can afford to purchase the materials on which industrial agriculture depends.

When inappropriately applied, industrial technologies also deplete soil, water, and other resources. Poorly designed and mismanaged irrigation systems can leave soil waterlogged or contaminated with toxic levels of salt. Loading delicate tropical soils with nitrogen fertilizers has acidified some of them. And heavy machinery and livestock can compact fragile soils, reducing their ability to support food crops.

Consider the "modernization" of rice production in Sri Lanka, where tractors are replacing water buffaloes as the principal source of power for plowing, tilling, and threshing. The conversion seemed to make sense at first, since it saves eight to nine worker-days per acre. But a closer look reveals significant problems.

When fuel prices skyrocketed in the 1970s, tractors actually increased farmers' expenses. Furthermore, milk and curd for the farm family, which the buffalo had long provided, now has to be purchased. Buffalo dung and urine were used to fertilize fields; now, farmers must buy inorganic fertilizers. Tractors have also wiped out buffalo herding as a source of employment for young villagers.

Beyond such economic difficulties lie subtler ecological tolls. The tractors have disrupted the formerly porous soil, the key to good crop yield and water retention. Removing rice-field pools traditionally kept as buffalo wallows has also obliterated critical "drought refuges" that in the dry seasons sustained organisms serving many useful functions. For example, farmers formerly harvested some 350 and 400 pounds of edible fish from each acre of wallows. Mosquito-eating fish also helped keep malaria-carrying mosquitoes in check; more insecticides must now be used to control malaria.

Two other beneficial species breed in the wallows. The rat snake is an important predator of rats and mice that would otherwise eat ripening grain. And the *Varanus salvator* lizard consumes freshwater crabs whose burrows weaken and destroy the levees necessary for good water management. The wallows also supply water for soaking the coconut branches used in thatched roofs. If thatch is unavailable and replaced by roofing tiles (which have to be fired), firewood demand increases and so does the already high deforestation rate.

The ecological linkages in this small example of a changing production system show the need to think much more clearly about proposed technological "improvements." Most traditional farming systems have evolved over centuries, even millenia, and the natural world has evolved along with them. The coevolution of wild animals and plants with human agricultural activities determines the functioning of whole farming systems. Any change should be undertaken with care.

The ecological effects of chemical fertilizers and pesticides on such a delicately balanced system can be severe. However, the cost and uncertainty of industrial supplies also makes them impractical for use by many poor Third World farmers. In landlocked Rwanda, for example, political unrest in neighboring countries has often interrupted supplies of commercial fertilizers and pesticides. The world over, poor road conditions, lack of vehicles, and diversion of chemicals to the black market can also disrupt the transport of critical supplies. Moreover, as former U.S. Agency for International Development (AID) administrator M. Peter McPherson recently remarked, it costs more to transport fertilizer from an African port to the interior of the country than to ship the material from the United States to Africa. In Rwanda, a ton of fertilizer that sells on the world market for $200 can cost $600 after being trucked from a Kenyan port to the final destination. And if those supplies are not available when needed, they are useless.

Beyond such obstacles lies the fact that poor Third World farmers simply can't afford chemicals that may not work. And poor communities clearly can't foot cleaning bills when the chemicals end up where

they don't belong. In short, Third World farmers need an agriculture that will improve their lives, not one that will impoverish them and the earth on which they depend. Indigenous—preferably renewable—resources must be the mainstay of their future.

Crop Mixing Means Bigger Yields

Traditional farming systems that employ more than one crop—in sequence, in combination, or both—work especially well both to boost productivity and conserve resources. Mixing crop and animal production works well, too. The Javanese home gardens of Indonesia exemplify the richness and inherent good sense in such polycultures. Studies of these small but highly productive plots—which account for 2.25 million hectares, or 17 percent of Indonesia's agricultural land—show that their ecological characteristics resemble those of natural forests. The gardens are incredibly rich assemblages of perennial and annual species: one survey recorded 607 plant species in 351 such plots.

Farmers who practice polyculture organize plants vertically as well as horizontally to take advantage of all available sunlight. The Javanese gardens contain at least four distinct canopy layers, from coffee and guava at the top to herbs and shrubs at the bottom, intercepting as much as 99.75 percent of the sunlight. Since the diverse plant assemblages rarely leave the soil uncovered, soil erosion is barely noticeable.

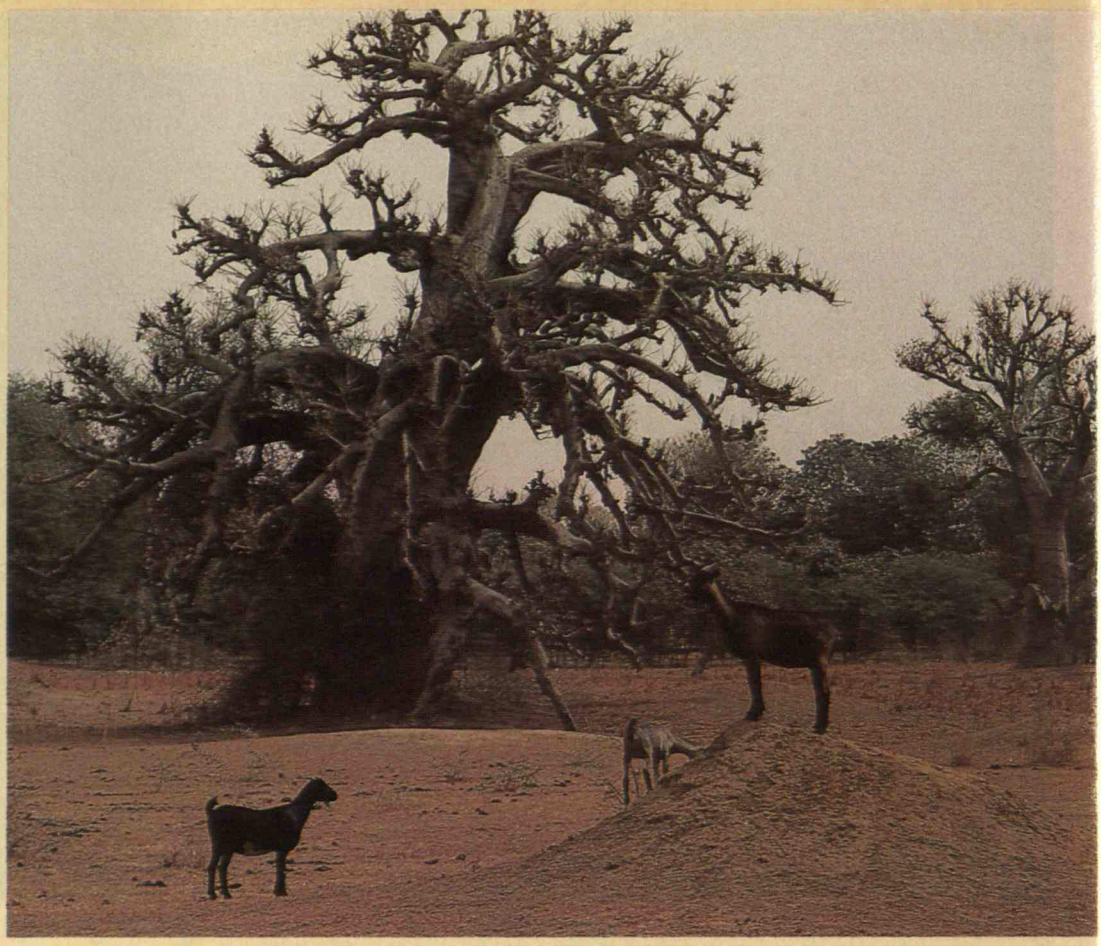
Agricultural scientists have found that yields from polyculture are often higher than those from monoculture. In Mexico, Stephen Gliessman of the University of California at Santa Cruz found that 1.73 hectares of land would have to be planted in maize to produce as much food as one hectare planted with a mixture of maize, beans, and squash. Chinese scientists have determined that a rubber-tea intercrop produces higher yields, reduces soil erosion by 70 percent, and raises the minimum temperature in the grove by 2° C, cutting the risk of cold damage to the rubber trees.

Comparing total biomass (as opposed to just food yields) reveals still greater advantages. A good mix of crops increases the soil's organic matter, if most of the noncrop biomass is plowed back in or fed to animals whose dung is used as fertilizer. This added benefit is a key to the long-term maintenance of the agroecosystem. Another Mexican study found that a maize-bean polyculture produced almost 4 tons of dry matter per hectare for plowing into the soil, compared with 2.3 tons in a maize monoculture.

Using Third World polyculture to ecological advantage makes sense, finally, because it is already so widespread. In Africa, 98 percent of all cowpeas—the continent's most important legume—are grown in combination with other crops. In Latin America,

PHOTOGRAPH: TERRY GIPS, INTERNATIONAL ALLIANCE FOR SUSTAINABLE AGRICULTURE

Farmers throughout the tropics practice slash-and-burn agriculture to clear land for crops, as in this area of Western Samoa planted with taro (middle). The technique releases nutrients to the soil and kills weeds. Yet if mismanaged it can quickly lead to severe erosion and desert-like conditions, as in this formerly rich Senegalese land (left). Far right: Traditional farmers mix crops—such as cotton and maize in Kenya (top) and onions and beans in Rwanda (bottom)—to keep weeds in check and make best use of nutrients and sunlight.



farmers grow from 70 to 90 percent of their beans with maize, potatoes, and other crops. Maize is planted with other crops on 60 percent of the region's maize-growing area.

Polyculture enhances yields and uses water and minerals more efficiently because different species have different nutritional requirements and discreet root layers. Deep-rooted plants can act as "nutrient pumps," bringing up minerals from deep soil layers to counteract leaching. The soil structure stays stable or improves as organic matter is added to the soil year after year. Where legumes are part of the polyculture, soil nitrogen (whose lack is often a constraint on increasing productivity) can be conserved, even increased.

Polyculture may also work to control pests. In some cases, chemicals produced by one plant may help another ward off attack by insects or plant pathogens. In others, different-sized plants may inhibit the movement and reproduction of pests or affect the visual or olfactory stimuli that help insects find food. In fact, one crop can sometimes be planted in barrier strips or "guard rows" around another.

Dense crop canopies can also keep weeds in check, though many traditional farmers know that some "weeds" may in fact be resources—in contrast to the "clean cultivation" that is a goal of many technologically advanced cropping systems. At low densities, for instance, weeds may offer little competition to crops but serve as herbs, pest-control aids, and medicines. A survey of noncrop plants in Indian ricefields found dozens of species with potential practical value. A broad view of the role of all plants in an agroecosystem—and knowledge of how to favor the combinations best suited to meeting human needs—could spare agriculture the expenses and environmental consequences of excessive weed control.

Agroforestry: Farming with Trees

Much of the diversity found in indigenous agroecosystems undoubtedly arose from economic need. A wide crop array means that something is always being harvested, so there is always something to eat or sell. Crop diversity also hedges against unexpected weather changes: if one crop fails because of too much or too little rain, another crop may survive or even thrive. And multiple cropping tends to spread labor demand throughout the growing season rather than concentrating it in peaks.

Yet scientists generally agree that indigenous multiple-cropping systems are not as productive as they

could be, and that modern plant breeding can be used to improve them. For example, some high-yielding varieties bred for use in more input-intensive industrial agriculture also do well in mixed-crop systems.

Another approach to improving both yields and sustainability focuses on the ecosystem rather than individual crops. Scientists and development specialists have become keenly interested in agroforestry—the blending of crops, animals, and trees to sustain long-term agriculture in the Third World. Spurred by deforestation, soil erosion, and the ever-growing need for both fuelwood and upland food production, agroforestry advocates in Africa, Asia, and Latin America have been exploring a wide variety of crop-animal-tree combinations.

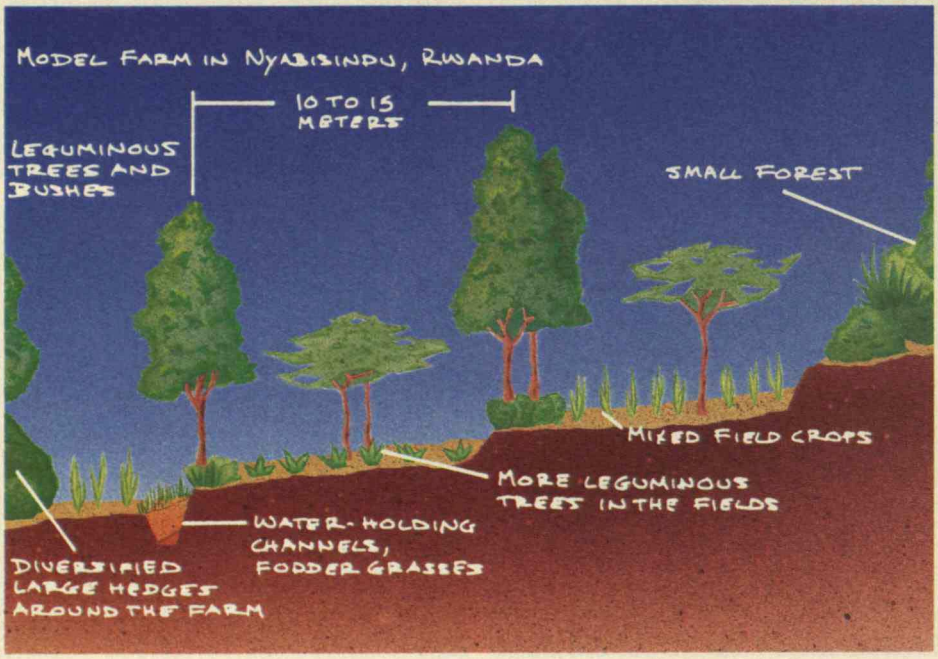
Aboriginal farming systems have probably always included trees. Farmers who practice ecologically sound shifting cultivation often spare trees of value for fruit or fodder. As trees regrow, farmers may sow some crops among them or harvest perennials planted at the beginning of the cycle. Some farmers plant seedlings of valued tree species that will mature during the fallow period, providing additional food, fodder, and firewood for years after annual cropping has ceased. Indeed, in Javanese home-gardens, where trees are freely interspersed with crops, the evolution from rice field to multi-storied garden is carefully controlled through adding and selectively removing plants over several years.

Besides providing useful products such as poles, fruit, edible seeds or beans, and fodder, trees also minimize nutrient drain from leaching and soil erosion and restore key nutrients by pumping them up from lower soil strata. In trials at the International Institute of Tropical Agriculture in Nigeria, the tops of leguminous *Leucaena* trees added to the soil contributed about 450 pounds of nitrogen per hectare in two years. The trees and maize were "alley cropped" (planted in alternating strips), which allows fertilizing and weeding in the crop rows while also retaining the benefits of intercropping. The trees grew so rapidly that weed growth was suppressed, erosion prevented, and soil fertility quickly restored.

The trees used in agroforestry must perform these functions without harming or competing with the understory vegetation. They should have relatively thin crowns to allow as much sunlight as possible to reach the plants nearer the ground. Ideal for many crop-tree agroforestry systems are leguminous trees such as *Acacia* and *Gliricidia,* as well as *Leucaena.* In situations where nitrogen fixation is less impor-

PHOTOGRAPHS: TERRY GIPS, INTERNATIONAL ALLIANCE FOR SUSTAINABLE AGRICULTURE; DALE BOTTREAU

Agroforestry—integrating trees with crops—can restore areas of Africa to productivity. At a project in Rwanda, trees stem erosion, add nitrogen to the soil, retain nutrients, and supply fruit and wood for housing.



tant, fruit trees, coffee, cacao, or coconut trees may be better choices.

Trees can help restore semi-arid areas of Africa to productivity. When Sudanese farmers leave the indigenous tree *Acacia albida*—a valuable component of traditional farming—in their fields, they can grow millet continuously for 15 to 20 years, compared with only 3 to 5 years without the tree. In Senegal, one researcher found that, when a crop-livestock-tree system was kept in balance, the land could support 50 to 60 people per hectare (several times the average for the region) with continuous cropping and no loss of soil productivity. In this system *Acacia albida* drops its leaves during the rainy season, releasing nitrogen and organic matter into the soil, and allowing light to reach the crops. In the dry season, the tree produces leaves and pods, providing fodder and shade for cattle whose dung further improves the soil.

Integrating trees with farming has been a key element in an African assistance program jointly sponsored by CARE and AID. In Chad from 1978 to 1985, CARE helped establish Acacia over more than 6,000 cultivated hectares. In spite of civil war and unfavorable weather, up to 80 percent of the trees survived. Other species were used to create living hedges and woodlots that protected gardens and cropland from grazing animals and provided villagers with much-needed shade, poles, and fuel.

At Nyabisindu, Rwanda—where intense shifting cultivation, fuelwood exploitation, and overgrazing have rapidly eroded the soil and attempts to introduce Western-style agriculture have failed—West German researchers have developed a complex system combining trees, animals, and crops. (*See the chart on page 34.*)

Building on indigenous practices, the West Germans are using trees and hedges to establish erosion-control strips that in turn yield fruit, wood, and fodder, protect the soil, and improve microclimates for plants and animals. Farmers plant pine, eucalyptus, *Leucaena,* and other trees at higher elevations where farming isn't possible. Perennial crops also help stabilize the soil. Organic fertilizing with animal manure, mulches, and compost serves to recycle wastes, raise the soil's humus content, and reduce leaching and soil-borne pests. Stabled animals feed on fodder crops and leaves from hedges and erosion-control strips. Local rocks provide mineral fertilizers where necessary.

A key to the project's success is a tree nursery that produces about 5 million trees annually. Intercropped with the trees are combinations of cash crops like bananas, coffee, and avocados and subsistence species like beans, maize, cassava, soybeans, and sweet potatoes. Fodder—including grasses, sorghum, and legumes—supplies food to livestock. Results from test plots indicate that a typical farm family using the mixed crop-tree system could produce 25 to 50 percent more fuelwood than it needs. Three-crop mixtures in the system have also provided 54 percent more calories, 31 percent more protein, and 62 percent more carbohydrates than monocultures.

Planning for a Sustainable Agriculture

International aid agencies continue to focus on setting up larger-scale, plantation-type farming projects to improve the Third World's balance of payments. To maximize production, these agencies also tend to

CHART: GARDINER MORSE, FROM F. BEHMEL AND I. NEUMANN

Bananas and mixed crops are part of the flourishing agroforestry system in Nyabasindu, Rwanda. Families now find they can produce the food they need as well as surplus quantities of fuelwood.

fund programs in areas where the potential is highest—the fertile lowlands, which make up a small percentage of the land area in most developing nations.

Yet there are some signs of change—including the Nyabisindu project, funded by the West German Agency for Technical Cooperation, as well as several Sahelian agroforestry projects supported by AID. AID now maintains a program of small grants for research in innovative technologies, and has a new policy of directing more of its project money through private voluntary organizations. Only time will tell whether these trends will persist and support an ecological approach to agricultural development.

To ensure that they do, we suggest that organizations like the World Bank and AID establish criteria for judging the sustainability of proposed projects. For example, if a project requires purchasing fertilizers and pesticides, the funding agency should spell out means for minimizing their environmental effects. The funding agency should also determine the reliability of supply and stability of chemical prices before the project starts. And funders should emphasize projects that substitute indigenous resources for imported industrial ones.

A bias toward an industrial model of agricultural development also pervades the policies of Third World governments. For example, a study by the World Resources Institute found that some Third World countries subsidize pesticide prices by as much as 89 percent, encouraging their overuse and discouraging investment in nonchemical controls. These subsidies should be eliminated. Governments also need to grant land tenure to farmers who conserve resources so that their investment of time and labor proves worthwhile.

On a more global scale, the U.N. Environment Programme, the FAO, and the World Bank should conduct a region-by-region "agroecological audit." Leading agricultural scientists should examine the sustainability of the world's farming systems. How well are they conserving and regenerating soil, using nutrients, preserving genetic diversity, and ensuring stability of crop yields and water supplies?

Agricultural engineers should also begin developing affordable equipment for Third World farmers who practice mixed-crop agriculture. Plant scientists can focus on improving traditional crop varieties and their natural relatives to help these farmers. Ecologists should play an important role in designing and implementing all such research programs so that the concepts and principles of ecology provide a firm foundation for all phases of development. □

PHOTOGRAPH: TERRY GIPS, INTERNATIONAL ALLIANCE FOR SUSTAINABLE AGRICULTURE

High-temperature superconductors are a scientific breakthrough, but technical and economic obstacles to useful applications remain.

Superconductors: The Long Road Ahead

BY SIMON FONER AND TERRY P. ORLANDO

Few developments have captured the imagination of scientists, politicians, and the public more quickly or thoroughly than the recent discovery of a new class of "high temperature" superconductors.

In January 1986, Karl Alex Müller and Johannes Georg Bednorz, scientists at the IBM Zurich Research Laboratory, discovered a ceramic material able to "superconduct"—carry an electric current without resistance—at about −238° Celsius, significantly higher than any previously known substance. Since then, researchers have pushed the threshold of superconductivity in ceramic materials even higher; some are even predicting superconductivity at room temperature. And last October, Müller and Bednorz won the Nobel Prize for their efforts, one of the most rapid recognitions of a major scientific breakthrough by the Nobel committee since the establishment of the prize for physics 86 years ago.

As scientists explore the characteristics of high-temperature superconductors, government officials are championing superconductivity as a crucial arena of international economic competition. In 1987 the Department of Energy doubled its funding of superconductivity research from $20 million to $40 million. The Department of Defense has developed a three-year $150 million research-funding plan. "The breakthroughs in superconductivity bring us to the threshold of a new age," President Reagan told a special federal conference on the commercial applications of superconductivity last July. "It's our task to herald in that new age with a rush."

Recent developments in superconductivity have inspired predictions of a technological revolution. But many proposed applications are far from commercial viability, and some are simply absurd. For example, storing enough energy to power the automobile shown on this magazine cover would require an impossibly large superconducting magnet. One weighing 100 pounds could generate about 130 horsepower—but only for a single second.

IBM researchers Karl Alex Müller (below) and Georg Bednorz received the Nobel Prize in Physics for their 1986 discovery of high-temperature ceramic superconductors. Their copper oxide, mixed with barium and lanthanum, was capable of superconducting at 35 Kelvin (the Kelvin scale measures the number of degrees Celsius above absolute zero).

Meanwhile, magazines, newspapers, and television have celebrated the promise of superconductivity to transform our physical world with everything from high-speed levitating trains to pollution-free electric cars, from wasteless power lines to hyper-fast computers powered by exotic new circuits. "The lightbulb, the transistor—now the superconductor revolution," runs one typical headline.

The discovery of high-temperature superconductivity is indeed exciting and important. And yet the more than 75-year history of superconductivity research suggests that we take some of the claims made for the new materials with a dose of caution—especially where discussions of applications are concerned.

After all, superconductivity is not a new phenomenon. It was first discovered by the Dutch physicist Heike Kamerlingh Onnes in 1911. It wasn't until the 1960s and 1970s that the first practical superconducting technologies were developed. And despite the growing use of conventional low-temperature superconductors in a variety of highly specialized applications, translating scientific breakthroughs into widely available technological options remains a difficult challenge, usually requiring years and sometimes decades of development.

This will almost certainly be the case for high-temperature superconductivity. There are still major technical barriers to the use of superconducting ceramics. In fact, they pose thorny materials-science challenges not experienced with existing metal-alloy superconductors. And even if practical high-temperature ceramic superconductors can be perfected, they will often represent only an incremental, as opposed to revolutionary, benefit over conventional superconductors or other competing technologies.

Most current or potential applications of superconductors can be divided into two broad categories. The first involves the use of superconducting material in large-scale technological systems, either as wire for the transmission of electricity or in magnets. Examples of the latter include magnetically levitated trains, high-energy accelerators, energy-storage systems, and nuclear magnetic resonance (NMR) imaging machines. Widespread use of these superconductor technologies will have far more to do with questions of public policy and economics than with the nature of the new materials.

The second category of applications involves the use of superconducting material as "thin-films" in small-scale electronic devices similar to semiconductor chips. Here, the new ceramic superconductors should have a more immediate impact, but it will still not be as radical as it first appears.

So while the science of superconductivity has taken a dramatic leap forward, in the absence of a further breakthrough—for example, superconductors that can operate at room temperature—the transformation of our physical world by superconducting technologies will happen considerably more slowly.

The Fragile State of Superconductivity

The excitement about recent discoveries is only natural, because superconductivity provides a means to eliminate one of the most fundamental technological limits of the electrical age—resistance. When the electrons in a current pass through a conductor such as copper wire, they bump against imperfections in the crystal structure of the material and scatter. The

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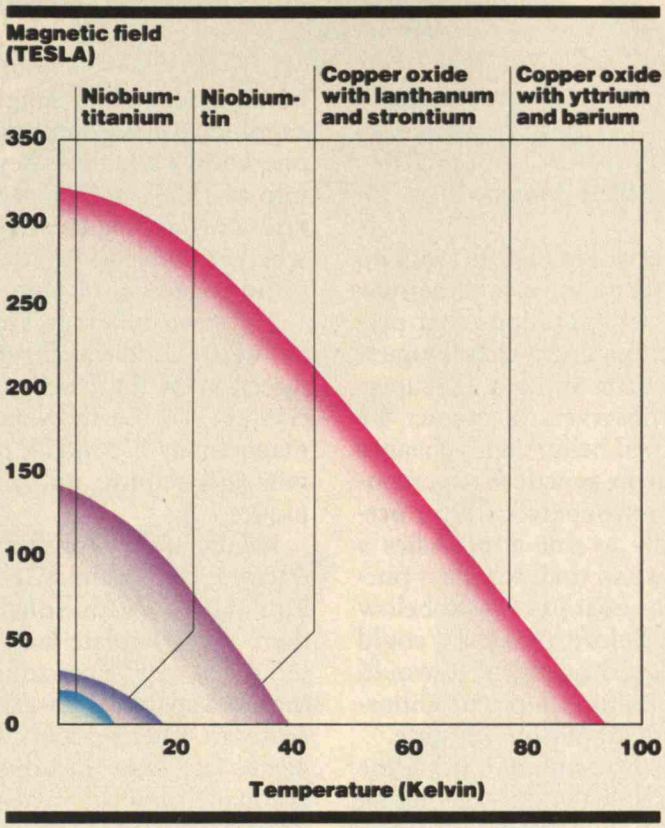
PHOTO: WALTER P. CALAHAN

This graph shows the temperature and magnetic field at which four different superconductors revert to the non-superconducting state. For example, at absolute zero, niobium-titanium stops superconducting at about 14 tesla (approx. 280,000 times the earth's magnetic field). At zero tesla, it becomes non-superconducting at about 9 K. The two copper-oxide ceramics are a significant improvement over the conventional superconductors niobium-titanium and niobium-tin. But technical limitations may block some applications.



result is resistance, a loss of energy through heat. The problem of resistance affects everything from how large a magnetic field you can have in a motor or transformer to how small you can make a computer before its components become so hot that they melt.

Superconductivity is a special state of solids—one in which an electrical current can pass through without any resistance or loss of energy. A current flowing in a loop of superconducting wire would continue forever, much as an electron circles an atom forever.

However, achieving superconductivity is a fragile process. It depends on three interrelated factors—the temperature of the conducting material, the strength of the magnetic field generated by the current, and the current density. Each of these three is crucial to the practical application of superconductors. Changes in any one can return a superconducting material to its normal state.

Nearly all the attention about recent discoveries has emphasized the first factor, temperature. Superconductivity depends on extreme cold, usually in the neighborhood of absolute zero, or −273.2° Celsius. As the temperature increases, the amount of superconducting electrons decreases until a given material ceases to superconduct. The point at which this happens is known as the "critical temperature."

Before Müller and Bednorz's discovery, the highest critical temperature on record was only −250° Celsius, or 23 Kelvin (the Kelvin scale measures the number of degrees Celsius above absolute zero). Using a superconductor with such a low critical temperature requires cooling it with expensive liquid helium to near 4.2 K.

Müller and Bednorz's ceramic (a copper oxide mixed with two rare-earth elements, barium and lanthanum) showed evidence of superconductivity at 35 K, the first increase in critical temperature in nearly fifteen years. A mere one year later, research teams headed by Paul C. W. Chu at the University of Houston and Maw-Kuen Wu at the University of Alabama discovered that a different copper oxide, this time mixed with barium and yttrium, would superconduct at up to 94 K, allowing it to be cooled with relatively cheap liquid nitrogen (77 K) instead of with the far more expensive liquid helium. Today, the highest critical temperature on record is in the neighborhood of 100 K.

The second factor that affects the ability of a material to superconduct is the presence of a magnetic field. The stronger the field at a given temperature, the fewer superconducting electrons. For every temperature, there is an "upper critical field" at which the material returns to its normal non-superconducting state. From a practical point of view, this is extremely important because one of the basic uses of superconductors is in magnets. A current is run through superconducting wire wound into a "solenoid," or coil. Because the current can pass without resistance, you can create far more powerful magnets with superconductors than with conventional materials.

The third and final factor affecting the ability of a material to superconduct is current density, the amount of electrical current it can carry through a given area. In general, the "critical current density" of a superconducting material—the point at which too much current causes it to return to a non-superconducting state—decreases as either the temperature or the magnetic field increases. This is important for many applications because the greater the current density of a particular superconductor, the smaller the magnet necessary to produce a given field. And small magnets mean cheap and efficient magnets. Fortunately, unlike critical temperature and critical field, which are basic properties of the materials used, the critical current density of a par-

CHART: TOM BRIGGS DESIGN AND GARDINER MORSE

Ceramic superconductors are more difficult to fabricate than their conventional counterparts, which is a major obstacle to their use in magnets.

ticular superconductor can be improved by techniques used in processing.

Technical Limitations of the New Materials

How do high-temperature superconductors stack up against these three critical factors? So far, the new materials have many technical limitations that prevent their immediate use in commercial technologies.

The high critical temperatures of ceramic superconductors have led many observers to predict the replacement of expensive liquid helium with cheaper liquid nitrogen as a coolant in practical superconducting technologies. However, superconductor performance deteriorates rapidly as one approaches a material's critical temperature so that, for most purposes, a given superconductor operates best at below half its critical temperature. Before a material could be efficiently operated in liquid nitrogen, it would have to have a critical temperature in the neighborhood of 150 K—considerably above any to date.

Many technical obstacles also remain to using the new ceramic materials in practical superconducting magnets. Most superconducting magnets in use today are made of the alloy of the metals niobium and titanium. It is ductile (so it is easy to form into the spiral shape necessary for a magnet), and when cooled to the temperature of liquid helium it can generate a field up to 9 tesla—nearly five times that of an iron magnet (1 tesla is equal to about 20,000 times the earth's magnetic field). Another commercially produced superconductor, a compound of niobium and tin, can generate even greater fields, up to 15 or 16 tesla. This material is brittle and therefore more liable to fracture under the strains of the forces generated by a strong magnetic field. However, scientists have developed ways to process niobium-tin so that it can be used in high-field magnets.

Because the new ceramic superconductors have high critical temperatures, one might expect that they have higher upper critical fields, and this is in fact the case. At the Francis Bitter National Magnet Laboratory, we have estimated that the upper critical field of the high-temperature superconductors is in the range of 250 to 350 tesla at absolute zero.

The first problem with the new materials is that they are considerably more difficult to fabricate than their conventional counterparts. Like other ceramics, they are brittle and break easily. They are also extremely sensitive to oxygen, water, and carbon dioxide, which suggests they may be highly susceptible to environmental degradation. So far, no one knows whether they can be reliably processed into the long lengths of wire necessary for winding into the complex configurations of a magnet or whether they can be adequately supported to withstand the forces of high magnetic fields.

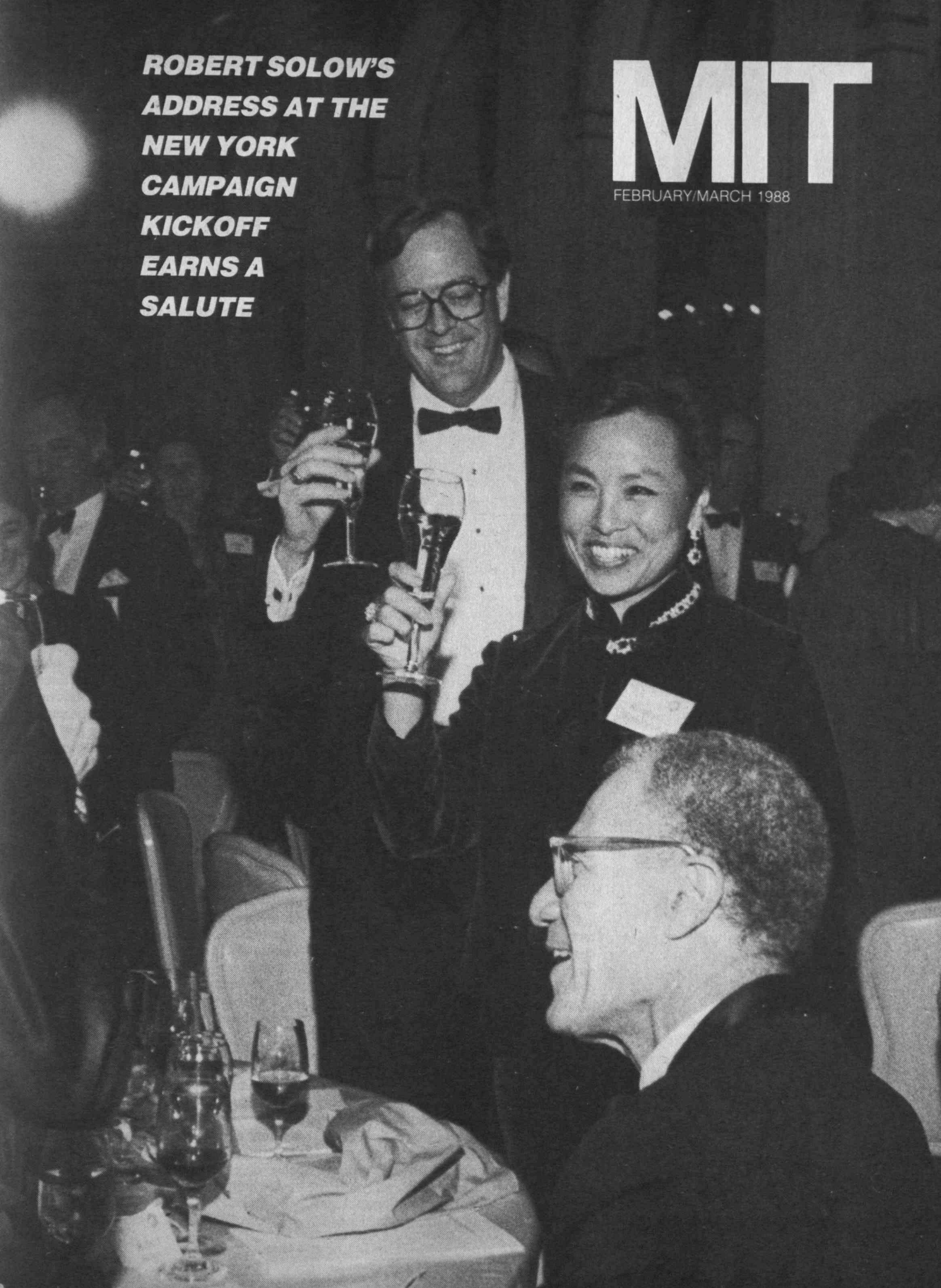
The new materials are also "anisotropic"—their ability to conduct current depends strongly on the direction of the current with respect to individual crystals. To use the superconducting ceramics in a magnet may depend on precisely aligning their crystals and require unconventional processing techniques.

Finally, unlike conventional metal-alloy superconductors, the ceramics seem to have a broad "phase boundary." With conventional superconductors, there is a complete lack of resistance until the material gets very close to its upper critical field. Then there is a sharp increase in resistance and the material ceases to superconduct. With the ceramics, resistance begins far below the upper critical field and increases gradually until the material becomes non-superconducting. At liquid-nitrogen temperatures, the new materials show signs of resistance at less than 10 tesla, approximately a tenth of the upper critical field that one would expect. If this broad phase boundary turns out to be inherent in the physics of the new materials, it could represent a major barrier to their use in high fields at high temperatures.

Perhaps the most serious shortcoming of the new ceramic superconductors is that their critical current density has so far been low. The most current density that bulk wires have been made to carry at liquid-nitrogen temperatures is only about 1,000 amperes per square centimeter at 1 tesla. But superconductors used in motors, generators, magnets, power lines, and electronic components must be able to carry as much as 100,000 amperes per square centimeter.

Again, no one knows for sure why the critical current density of the new materials is so low. In the samples tested so far, it appears that the ceramics consist of individual superconducting crystals with non-superconducting areas in between. The superconducting current is not continuous; rather, it "jumps" from crystal to crystal by a process known as "intergranular conduction." This and the ceramics' anisotropic character could be the source of the current-density problem.

(Continued on page 42)



MIT

FEBRUARY/MARCH 1988

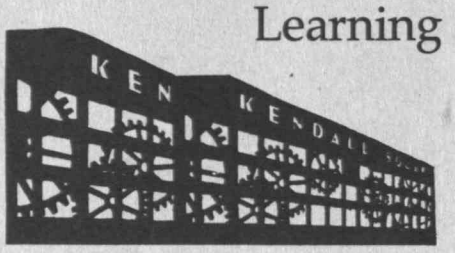
ROBERT SOLOW'S ADDRESS AT THE NEW YORK CAMPAIGN KICKOFF EARNS A SALUTE

MIT

FEBRUARY/MARCH 1988

ABOUT THE COVER:
The New York kick-off for the* Campaign for the future *was also a tribute to Nobel laureate Robert M. Solow. David Koch, '62, and Rosalind Whitehead are the most visible of the hundreds who raised their glasses after an address that would have prepared his audience very well, indeed, for a threatened "quiz tomorrow."
(Photo: Arthur Krasinsky, KPI Inc.)

Learning to Learn



COOP'S NEW HOME
Amongst the bon mots about urban renewal in Kendall Square (*July, pages 4-9*)—including the tragic demise of the F&T, one of the few great hangouts near the 'Tute—was a quickie about the Coop moving to new quarters. This was in fact major news to those of us who still belong to the Coop, get there too rarely but often order by phone or mail. Please supply further information. And what is happening to the old Coop space in the Student Center?

LEONARD LEVIN, '66
Palo Alto, Calif.

The Coop's new address is 3 Cambridge Center, Cambridge, MA 02142, (617) 491-4230. The Student Center space is being refurbished for new food services and stores that will include Toscanini's ice cream, Newbury Comics, a travel agency, and a bank, with leases soon to be signed and renovations finished by September 1988.—*Ed.*

HUMANITIES: GOOD BUT COULD BE BETTER
The letter from Jack K.Y. Hum, '38, on humanities courses at M.I.T. (*August/September, pp. MIT 2-3*) was a trigger to my own memories.

Over the years I, and many of my technical colleagues with whom I've discussed these issues, have had to revise our thinking on the validity of certain college courses. I've come to a number of interesting conclusions:

1. In-depth technical courses rarely have long-term validity. This is most true in areas like computers, where no course that I took 20 years ago is appropriate today.
2. Learning how to learn, and the interaction with creative professors and other students, is more important than specific course content. (Though content certainly seems to have something to do with getting that first job!)
3. Of the many college graduates I've hired in the last 10 years, the best have turned out to be those who have a strong technical base, like to learn, are creative, and are dedicated to getting the job done. Any specific new discipline can be rapidly mastered by anyone with these traits.
4. As one moves into management (and I've been there for some time), insights into accounting and psychology are critical. I'll never be able to handle balance sheets as well as accountants do, but I certainly have to fully understand what cost-effectiveness means in a business world. Similarly, though I need not know Freud or understand the workings of the brain, it is critical that I understand how to work well with peers, subordinates and management. I'm amazed at how much useful material I gained from Organizational Psychology, as taught by Professor Thomas Allen.
5. I enjoy classical literature, music, and other arts covered in the Humanities curriculum, and I do not regret taking those courses. But they basically provided the kind of rounding I like but do not necessarily need; they are not really critical to my work.
6. My last and probably most important point is that I have found that many of my business colleagues cannot write, present a cogent technical brief, or make an effective presentation. These skills—more than any others—are required to get ahead in any job. Even the most specialized engineers must "sell" their ideas. I regret that M.I.T. never really prepared us for that major function.

I hope that these views may influence, in some way, the direction that M.I.T. takes as it continually re-evaluates its humanities program.

JOHN P. RUDY, '67
Lexington, Mass.

A simple but unacceptable solution to the humanities problem (*see "Assessment and Change in Undergraduate Education," October, pages 13-27*) is to make engineering a graduate department, with students required to have three or four years of college undergraduate studies before being admitted to engineering.

PHILIP H. SCHWARTZ, '23
Pasadena, Calif.

Electricity for Campesinos in a War Zone

On April 28, 1987, Benjamin Linder, an engineer from Portland, Oregon, was ambushed and killed by United States-supplied contra forces in northern Nicaragua. The first U.S. citizen to die in an attack by the military units, Linder had just completed a small hydroelectric plant and was beginning work on a new one. Rebecca Leaf, '82, his friend and colleague, took on the completion of the project on which he was working. The following are excerpts from an interview conducted by Dana Moser in Managua, Nicaragua, in July 1987.

MOSER: Could you start with a quick sketch of your background?

LEAF: I went to M.I.T. in two phases: once in 1970-71, and then again in 1979-82, graduating in 1982 with a bachelor's degree in mechanical engineering. I returned that second time with the idea in mind that I wanted the best engineering education I could get and I wanted to use it in a Third World country.

After graduating, I had an opportunity to come to Nicaragua to visit a friend of mine who was teaching forestry here. I saw a lot of enthusiasm for development projects in the country, and that was just the way that I had wanted to use my engineering: on projects that were aimed at improving the livelihood of people living under conditions of severe poverty. Ben Linder took my resume to the Energy Institute of Nicaragua, which is like a combination of the U.S. Department of Energy and a public utility company rolled into one, and I was hired.

MOSER: So Nicaragua presented the first opportunity to test your interest in working with people who are rebuilding from a situation of poverty?

LEAF: I was also very interested in the whole revolutionary project here. It was something that I really wanted to see up close, to learn how it was working and what the truth was about it. I've seen a lot of support [for the revolution] here in the countryside, in the city, in the poor neighborhoods. The people are organizing themselves, developing community projects, and fighting to defend the projects. It's not something that's being designed somewhere else and put into practice by people who have some theory about it. Rather it is an organic process that's happening in society.

MOSER: What exactly is the work that you do for the Energy Institute?

LEAF: Nicaragua has six major power plants—petroleum burning, diesel burning gas turbine, geothermal, and hydroelectric—that provide all of the electricity for the Pacific side of the country. On the Atlantic coast there are isolated diesel generating units. There's a shortage of technically trained people and engineers in the country, so the Energy Institute formed a Technical Division here in Managua. We are sent out to try to help with planning and supervise maintenance in those major power plants.

They mostly gave me problems in the petroleum-burning plants and the geothermal plant, because my strongest background is in heat-transfer, fluids, and thermodynamics. So, I've had to deal with heat exchangers that are corroded and need to be rebuilt. We don't have the appropriate tubes, and have to redesign using the parts that we have so that the plants can keep running.

MOSER: What is the impact of Nicaragua's political situation on the development of energy?

LEAF: The Nicaraguans don't want to be dependent on imported petroleum anymore. They are trying to develop more of their geothermal and hydroelectric resources. They have the designs for various hydroelectric sites, but those are all in the northern mountain areas (the war zones) and it's really too dangerous to build a large-scale project there. Construction on a second geothermal unit, scheduled to begin a year and a half ago, was delayed until just six months ago, because the United States cut off Nicaragua's access to international loan money. The American action is slowing the development of energy resources.

MOSER: As a woman working in Nicaragua, have you ever experienced discrimination?

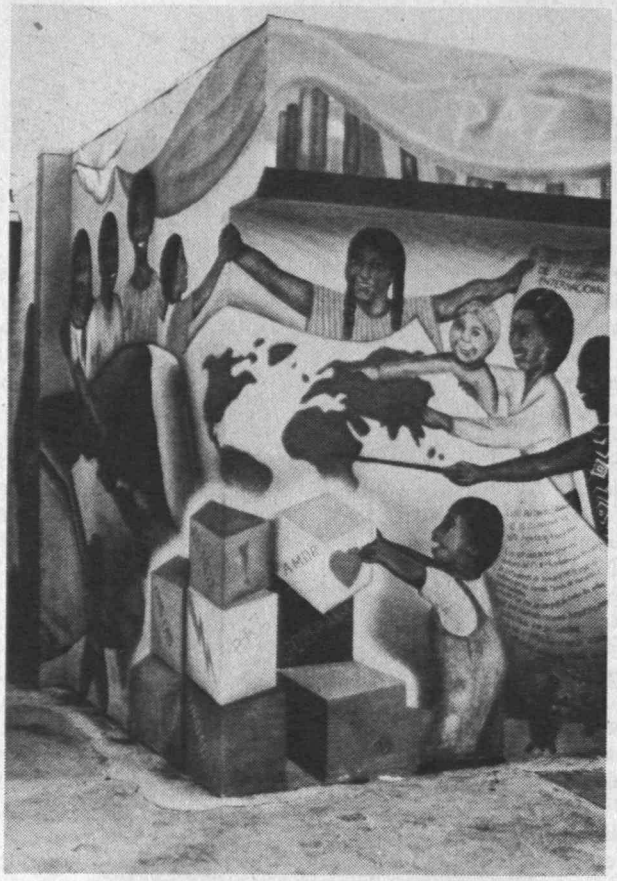
LEAF: Being a foreigner here is very much more important than being male or female in an engineering job. The fact that I have an engineering degree from a foreign university makes me somebody who's expected to know something, and somebody who's consulted about problems. I had to prove some technical capacity in the beginning to merit that status, but there have been very few cases where I felt that my being a woman made a difference in my professional work.

MOSER: What are you working on now?

LEAF: I'm just getting into the small hydro work. That was what Benjamin Linder was doing. He and I lived for about

DANA MOSER is an artist, filmmaker, and musician. He lives in Boston and teaches in the Department of Media and Performing Arts at the Massachusetts College of Art.

PHOTOS: DANA MOSER



The local community covered this small library with murals, but according to filmmaker Dana Moser, they can't get books to fill the shelves.

a year and a half in the same house; after hearing him talk about his project, I had good background knowledge.

MOSER: How did it affect your feelings about your work here, to have a friend killed who was working on a project like the one you're starting now?

LEAF: The first reaction was outrage. And then the second reaction was to feel a stronger commitment to keep on with the work that we had been doing. That seems to have been universal among the internationals that I've spoken to. In my particular case, after working in Nicaragua for two and a half years, I had been thinking about going back to the United States to get some more experience and return. But since Ben was killed, I've decided to become more involved in the work in the northern mountain zone where Ben was active.

MOSER: How are development projects possible in those areas, given the level of danger?

LEAF: Many Nicaraguans have been kidnapped or killed trying to do development work in the war zones. Telecommunications workers, doctors, nurses, teachers, and religious people have been specifically targeted and ambushed by the contras. Any productive activity in those areas becomes an object of attack. Yet if you visit those communities, you find many people continuing to carry out agricultural development work, adult education, or health work with great determination and great consciousness of the risks that are involved. They feel strongly that they have the right to development, even in a war zone. And I feel that those of us who support that belief should stand firm with them.

The project in El Cua involves the development of about a dozen small hydroelectric plants in a northern mountain area that has a long rainy season and a lot of streams. Benjamin and others had identified the various sites that were close to towns or cooperatives where hydro power could be developed. The project has been very successful.

The first plant, 100 kilowatts, is now operating. They've built a small mechanic shop and have acquired a welding machine, so they can repair vehicles and farm equipment. The electricity provides for refrigeration, storage of vaccines, operating a health center, and light at night for adult education.

The hydro projects are linked to others in the zone, including drinking-water systems, housing, and adult education. Before, there were no schools whatsoever in this part of Nicaragua. And now there are, I think, 13 schools and 40 teachers provided by the Ministry of Education.

MOSER: What was Benjamin working on when he was attacked?

LEAF: For two and a half years, Ben had been traveling up to the zone for periods of a week or two, working on the first plant. Because there was no electricity at all, no welding machine, no machine shop, no mechanics, and hardly any tools, he had to keep carrying machine parts down to Managua for repairs. In November 1986, they had the first electric plant working along with a small machine shop, and Ben moved to the war zone full-time.

The first step in developing all of those potential hydro sites is to build "weirs"—little dams with a notch at the top. Water falls rapidly through the notch, forming what is called a "free-outfall." It gives a certain curvature to the surface of the water that changes according to the flow. If you put a stake in the water upstream from the weir, you get a reading that can be plugged into a formula to calculate the flow rate. Ben worked with a couple of people from the cooperatives, or *asentamientos*, to build these little dams. They needed to know the flow-rate, in both the wet and dry seasons, to plan the equipment for the power plant.

MOSER: So at the time of the attack he was . . . ?

LEAF: Ben was halfway through building one of those weirs. Two Nicaraguans were killed with him in the attack, Pablo Rosales and Sergio Hernandez. They were both from an *asentamiento* just to the north of Bocay, which is the town served by the power plant. The week after Ben had been killed, the people from the power plant project in El Cua and several people from the *asentamiento* volunteered to finish building the weir. And they wrote in the fresh cement in the top of the weir, "*Aqui caio Benjamin Linder. Su obra seguira,*" which is, "This is where Benjamin Linder fell. His work will carry on." And on the other side they wrote, "*Pablo Rosales, Sergio Hernandez. Presente,*" which means that those people are still with us in spirit, and carrying on the work. The fact that the weir was finished within a week of when Ben was killed, I think, says the key thing about the project: the people involved, as well as the people in the communities, felt that it was valuable.

MOSER: Do you think Benjamin was specifically targeted?

LEAF: Yes, I think so. He was obviously a foreigner. He was very light-skinned and had glasses that were very uncommon here, was foreign in the way that

he spoke, and was well-known in the zone. He'd been coming up there for three years, so a lot of people knew who he was.

And the way the attack was carried out, the contras were there in hiding, waiting for him. For four or five days the work team had been going up to the site, carrying bags of cement, making the wooden forms, and carrying on the work of making this small dam. Somebody who had been observing them knew that they were coming up, and it was a chance to ambush them. The circumstances indicate that it was a carefully planned job. The contras wanted to destroy the project because it represents an advance for the community. The contras don't want them to benefit from activities supported by the Sandinistas.

MOSER: Technically trained Europeans have been killed by contras for several years now, but this is the first time an American has been murdered. Do you think this represents a policy shift to try to frighten away people exactly like yourself?

LEAF: I do think so. A lot of European governments were paying their own nationals to work in Nicaragua. The Germans and Swedes, for example, were working in forestry, agriculture, and other projects sponsored by their governments. Religious groups and nongovernmental organizations similar to Oxfam also sponsor projects. There are thousands of European-supported programs in the country.

By killing workers on sponsored projects, the contras managed to scare the European governments. The sponsors threatened to cut off aid to Nicaragua if there were more deaths among their nationals. In response, the Sandinista government was forced to ask all of those people working directly through their government money to come down out of the isolated areas into the cities.

That was the object of the contras, to discourage the European support for projects in rural areas; so I assume they wanted to kill an American for the same reason.

MOSER: How do you feel about the coverage in the U.S. news media of the war in Nicaragua and of Ben Linder's death?

Thanks to a hydroelectric project, there will be lights for adult education classes at night in this rural school—the first in its district.

LEAF: The State Department and the C.I.A. have an obvious position on the war. That is, they want the war to continue, and they want to see the Sandinistas crack and fall. Therefore they present a lot of what purports to be information but is sometimes blatantly false.

A case that I recall was at the time that the Miskito Indians were being relocated from the Rio Coco. Jean Kirkpatrick and Alexander Haig were saying that the Sandinistas were "practicing genocide," that they were killing all of these Miskitos, that they were herding them into concentration camps. And they showed photos of bodies being burned in Nicaragua, which they claimed were the Sandinistas burning their Miskito victims. Those photos turned out to have been taken by the Red Cross, and they were pictures of Red Cross workers burning the bodies of people who had died in Somoza's bombing raids.

It's a good thing that there are many Americans who travel here to try to see for themselves what's going on.

On the treatment of the issue of Benjamin being killed: We are all more intensely moved by the loss of someone with whom we can readily identify. Benjamin was an American. Some people had seen the photos of him in his clown suit entertaining children, and people knew that he was an engineer working on a project to bring electricity to an isolated rural area. All those factors are familiar to the U.S. culture; they are positive values for a person to have, so people see him as a valuable person. Then it strikes them strongly that such a person could have been targeted for murder and possibly tortured by the contras. I think that's why there has been continual coverage of the story.

Contrast that with the media response to the deaths of thousands of Nicaraguans. I was in Esteli one time when a busload of people had gone out to pick coffee and was attacked by the contras. Eleven coffins were carried into town late at night. It was a very wrenching scene to see the families come and look at the bodies through the glass cases on the coffins, trying to recognize which was their son or daughter, brother, sister. The bus had been set on fire, and some of the bodies were burned beyond recognition. It was a terrible scene and it affected me a lot.

On another occasion, I was taking spare parts to a sewing cooperative and met a woman in the cooperative who had been a farm worker. She told me about a cousin who had been out working in the field when the contras came and insisted that he join them. He refused. They tortured him to death, pulled out his eyes, and hacked him up with a machete. She and other members of the family and friends had to go down to the field and bring his body back up to the church for the Mass. She described that to me, and her eyes were burning with the emotion of it a year later. She wanted to convey to me, as an American, especially, what had happened; to try to make it real for me so that I would feel it. So I've felt these other deaths. But none of those deaths affected me as much as Benjamin's. That's the way human emotions work.

MOSER: What is the best way for people working in the United States to support the work that you are doing?

LEAF: It's important for Americans to try to work to defeat government and private aid to the contras. What development work here needs most is peace. □

Across Australia by Sun and Grit

Five M.I.T. students conquered 2,680 kilometers of the Australian outback to claim ninth place in the 1987 World Solar Challenge.

Despite countless breakdowns and a serious electrical fire, the 320-pound solar automobile fielded by a team of M.I.T. students finished ninth out of 24 contenders in the Pentax World Solar Challenge in Australia last November.

"It was a tough race" was the understated description of the event by James Worden '89, designer of the solar-powered automobile, *Solectria IV-B*. What made it tough was 11 days of driving in temperatures averaging about 100 degrees, over narrow roads paved with half-inch pebbles (and some unpaved detours) that *Solectria* shared with fast-moving Australian double- and triple-trailer freight transporters.

Solectria's designers had been warned about possible danger because of air turbulence in the wakes of passing trucks. So they gave *Solectria* a stiff suspension system—hard tires, unyielding springs. The real problem, however, turned out to be not aerodynamics but the coarse road surfaces, for which the suspension system was all wrong. So there was lots of vibration, lots of unexpected stress on both vehicle and drivers, and lots of trouble as a result.

The route celebrated the recent "paving" of Australia's Stuart Highway, the only road from Darwin on the north coast due south to Adelaide on the south coast. Almost all the route is "outback"—hot, scrubby desert with few inhabitants except wombats and kangaroos.

Entries ran the gamut from professionally-built vehicles such as those from General Motors and Ford down to student-built machines. The M.I.T. team says that *Solectria* compared favorably with cars launched by some of its academic-based competitors, including the Darwin Institute of Technology and the Ingenieurschule Biel of Switzerland. Apparently M.I.T. sent the only student-designed vehicle and the only all-student team in the race—no professionals, no faculty advisers.

To finish ninth under these circumstances is no small victory. It would not have been possible, says Worden, without help from several sponsors—M.I.T.'s UROP program, Dow Chemical, United Airlines (air transportation for the team), General Motors (air transportation for the car), Arco Solar (solar cells for *Solectria*) and many others who contributed parts and supplies.

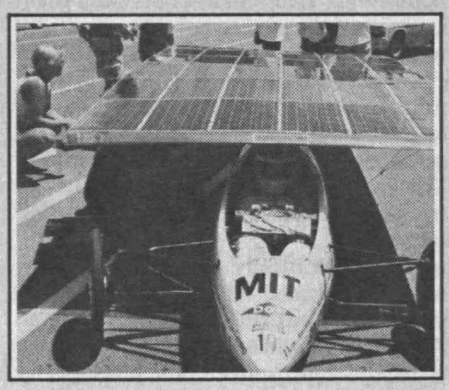
Australian alumni were a crucial factor, too, especially chemical engineer Brian Mellor, S.M.'52. He met the team in Syndey, travelled with them to Darwin, and drove his own car as a support vehicle throughout the race—cheering them on, helping solve problems, and camping with them in the desert. Later, John Morphett, M.Arch.'57, hosted the team at his home near Adelaide at the end of the race, and the hospitality of John Bertrand, S.M.'72, and Robert Nordlinger, '69, gave them a chance to see Melbourne before coming home to Cambridge.

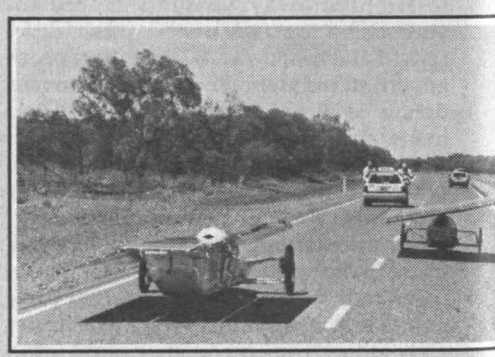
Worden's teammates in Australia were Catherine Anderson,'90; and graduate students Gill Pratt, Megan Smith,'87, the project's chief fundraiser; and Robert J. Webster, Jr. Worden, Anderson, and Smith are in mechanical engineering, Pratt and Webster in electrical engineering. Left behind them in Cambridge were eight enthusiastic teammates who had devoted much of the fall to *Solectria*'s construction.

If Something Can Go Wrong . . .

The *Solectria* project really began in September, less than three months before the starting gun was to be fired in Australia. Time, therefore, had been the main stumbling block from the beginning. As it turned out, the vehicle had only three hours of road testing before it was sent overseas, and laying in a proper supply of spare parts was impossible.

Troubles were expected, and every entry had them. The M.I.T.'s team's first emergency arose during what the Australians called "scrutineering"—prerace inspection—four days before the start. A guy wire from the 13-foot solar panel touched the battery cables during a battery change, causing an electrical spike that badly damaged the AC motor's position sensors and controller. The controller is a key component—it regulates the electric flow between the solar cells, battery, and motor. Pratt, the





Scenes on the Stuart Highway from the start at Darwin (top) to the end, when time ran out, 2405.2 kilometers later. Right: Anderson brazes the failed panel brace on day 8.

PHOTOS: GILL PRATT, ROBERT J. WEBSTER, AND IKE TRELOAR

In the hot sun down under, 8500 miles from home, the student team poses with Solectria IV—(left to right) Gill Pratt, James Worden, '89, Robert J. Webster, Jr., Catherine Anderson, '90, and Megan Smith, '87. At the right is Australian supporter Brian Mellor, S.M.'52, and at the far right Webster and friend near Adelaide.

solar cells, battery, and motor. Pratt, the team's electronic specialist, had to replace the damaged parts with backup systems that had been reserved for the race.

Just one day before the race, the car seat burst into flames while Worden was in the vehicle. The epoxy seat contained highly flammable carbon fiber, and it ignited when the insulating tape between seat and batteries failed.

"Cathy Anderson saved the day and probably my life," Worden remembers. "She pulled me out of the car and put the fire out with her own hands and breath by blowing and batting the flames." So Worden escaped with only singed hair and a scorched shirt.

"But we were pretty bummed out over the fire," Pratt recalls. "It was clear James could have been hurt. It really scared us"—so much that the team considered withdrawing from the race. But after weighing possible risks and installing a new masonite seat in *Solectria* and a fire extinguisher in a support vehicle, they decided to continue.

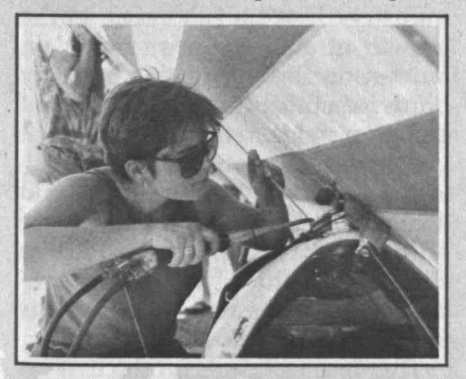
As the race began, *Solectria* made a good start under sunny skies. But within two hours everything stopped. The backup motor controller had failed and had to be replaced with the third and last backup controller. The same day saw four flat tires; repairs were quick, but they absorbed most of the team's stock of spare tubes. On the other hand, with full sun on the solar cells, *Solectria* proved to be very fast: cruising speed was at least 50 kph.

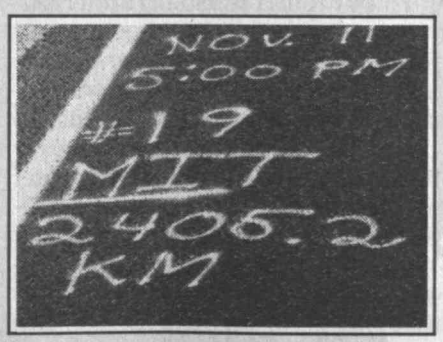
On the second day, *Solectria* encountered hills. Since most of the route would be flat, and because of the original motor's high torque, Worden had opted not to install the transmission that would have helped the car climb hills. It was a crucial error: heat from the overtaxed back-up motor caused its magnets to "demagnetize," according to Pratt, and the motor gave up the ghost.

The result was little short of panic, recalls Worden. "We didn't have a backup motor and we were in the middle of the outback. . . . Gill started working madly to get the original AC motor to run, and Cathy and I went to the closest town to try to find a DC motor." After a dozen frantic phone calls, Worden finally found a competing team from an Australian high school that was willing to sell a spare motor for $500.

Amazingly, the M.I.T. team lost only half a day to this mishap. But Worden says it was one of those episodes about the race that "I just want to forget about. . . . Again and again I banged my head saying, 'We should have done more road-testing.' "

Now *Solectria* was running well, and the M.I.T. team cruised steadily under cloudy skies for the next six days. The lack of direct, sustained sunshine reduced their speed to about 25 kph, but drivers Worden and Anderson managed to pass many cars during the sixth and seventh days of the race.





● Adelaide

FINISH

Then on the morning of the eighth day, more trouble: the team emerged from their tents to find a slow leak in a rear tire. And while Anderson was changing the tire, she accidentally damaged the bead with a tire-iron. The ensuing scramble for a 17-inch spare tire cost two more precious hours.

The final test of the M.I.T. team's tenacity came when the forward brace carrying the solar panel snapped as *Solectria* maneuvered through a bumpy detour. So began a series of attempts with a brazing torch, first by Anderson and finally by a local blacksmith; each failure cost precious time.

According to the competition rules, the race would end five days after the first car finished. That deadline came on day 11, when *Solectria* was 350 miles from the finish line. Five cars had reached that goal and three more were ahead of *Solectria*, giving Worden fresh grounds to bang his head—but plenty of grounds, too, to be proud of his car and his colleagues. (GM came in first.)

There's Always Another Race

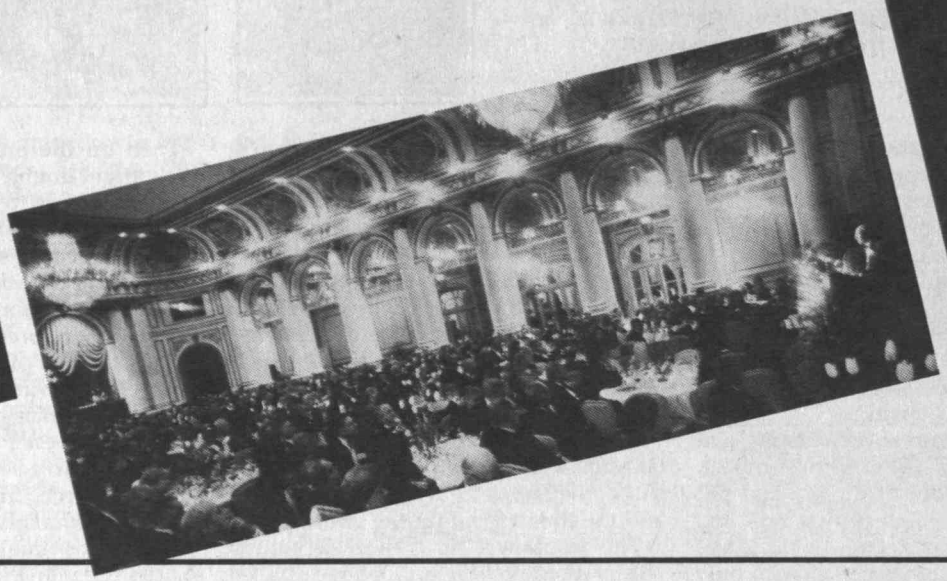
Now Worden is gearing up for the Tour de Sol, a six-day course through the mountains of Switzerland to be held next June. It will be the third time Worden has entered that race, the second time with an M.I.T. team.

"We're really psyched for the Tour de Sol," he said. "We plan to have the new car rolling by the end of January. And we're going to test the living daylights out of the machine, long before the race."

Worden, Anderson and team member Erik Vaaler, a graduate student in mechanical engineering who serves as technical adviser to the team, are teaching an IAP course on solar car design and construction. Thus many students are having hands-on experience building the *Solectria V*, the team's next model. □

This article is based largely on reporting for The Tech *by PAULA MAUTE, senior secretary in the Department of Architecture; used by permission.*

Solow: Short-Run Gain or Long-Run Health



When M.I.T. launched the New York City segment of the Campaign for the future *on December 3, the keynote speaker was Professor Robert Solow. Only a week later, Solow, described in the* Economist *magazine as one of the "giants of Keynesian economics in the post World War II period," went to Stockholm to receive the 1987 Nobel Prize in Economics. His New York address, showing why he is as famous for his wit as his economic insight, and was the high point of the evening. Here a condensed version.*

I want to talk about "The Short Run and the Long Run," because it has struck me very forcibly in the past six weeks that although I was given this Nobel Prize for work that I did 30 years ago to study the fundamental basis of the long-run growth of industrial economies, everybody I talk to these days wants me to talk about last week and next week. We seem in the United States to have eyes and ears only for the short run. I wonder if that's true in other countries as well.

I also wonder if it's true in other subjects. My colleague Susumu Tonegawa won the Nobel Prize in medicine this year for having done fundamental work on how the human body reconstructs its immune system. I've been wondering, do people come up to him in the street and say, "Professor Tonegawa, what should I do about this rash I have on my arm?"

Economic policies can have one set of effects in the short run and a quite different set of effects in the long run. That happens because most of the time in private enterprise economies, in the short run, the level of production is determined primarily by what happens on the demand side, by the buying of output. Whereas in the long run, most of what happens in our economy is determined by the supply side, by the production of output.

To put it in a nutshell, under private enterprise, in the short run we produce what we can sell, and in the long run, we sell what we can produce. It's not always true, but it's close enough, and it makes a very big difference. Currently, the chief example of this deep truth is the federal government budget deficit.

Everybody in this room, like everybody in the Congress, knows that they're against the deficit. But I find that nine out of ten people, especially in the Congress, don't know why they're against it. I want to tell you the economist's reason why: We don't save a lot in the United States—that's just a fact—and the Treasury's deficit absorbs a lot of that saving.

The Treasury, when it goes into the market to sell its bonds, will sell its bonds, come what may. Every dollar of scarce saving that finds its resting place in a Treasury bond is not available to be used to finance productive investment in American industry. That's a hindrance to the growth of our economy, and it's a burden on the future. It's the only burden on the future that the federal deficit provides; the rest of what you've read is just metaphor.

A smaller American deficit could mean, therefore, a larger and more efficient capacity to produce in the future—and then I say the economist's magic phrase, "other things equal." I'll come to that.

That loss of future productive capacity is why you're against the budget deficit. I want you to remember that—there'll be an exam tomorrow morning at 9 o'clock.

What I've just given you is the

PHOTOS: ARTHUR KRASINSKY, KPI INC.

Scenes from a New York spectacular: Architect Ieoh M. Pei, '40 . . . the Plaza Hotel ballroom . . . philanthropist Jack Whitehead . . . Jim Levitan with Milena Roos . . . Betty and Howard Johnson with chemical engineer Ralph Landau, Sc.D. '41, donor of M.I.T.'s Landau Building . . .

long-run answer. In the short-run, from quarter to quarter or year to year, that budget deficit has been a support for the economy. When the government buys goods or when it transfers income to people who spend everything that they get, and does it without reducing private purchasing power by taxing, the government adds to the demand for goods and services. By doing so, it adds to output and employment in our economy—provided there is not already excessive demand for goods and services in the economy. Most of the time, such is the case.

If we now, for instance, did nothing else but reduce the federal government's expenditures, or increase its tax revenues, other things being equal, we would reduce production and employment in the short run, and quite possibly we would reduce productive investment as well. Why? Because in the short run, if we can sell less, we'll produce less. Whereas in the long run, if we can produce more, we'll sell more. That's hard. That won't be on the exam in the morning.

What I just said is not a paradox. It's just a reflection of the fact that the demand side of our economy is predominant in the short run and the supply side is predominant in the long run. That makes for a policy dilemma for the United States right now. The solution to the policy dilemma, of course, is to be clever.

There are probably ways of reducing the budget deficit and at the same time offsetting the contractionary effect that extracting purchasing power from the economy would have. The obvious way is through monetary policy and lower interest rates, and it is for this reason that I wish the Federal Reserve had been more directly represented in the most recent round of federal budget negotiations.

I don't know if you have been struck as I have been by the fact that the budget negotiations went on between the White House and the Congress as if they were enemy powers, as if the President were negotiating with the Parliament of Bulgaria instead of the Congress of the United States.

The other possibility for limiting the contractionary effects of deficit reduction is through international action to expand our net exports. That could be done either by depreciating our currency and/or by stimulating the overseas economies that have large trade surpluses.

This brings me to a second application of this difference between the way things look in the short or long run. I'm not being a shrinking violet here, I'm going to take the other big problem—the balance of payments—and look at that from the point of view that I've been trying to push on you.

If we consider economic factors under the control of the United States alone, one of the main devices that we can employ to improve our export-import balance in the short run is to have a recession at home. We *can* do that and we might, believe me. And the second device is depreciation of the dollar.

Both of those things, having a recession and allowing the dollar to fall, are ways of making the United States poor. But depreciation of the currency is surely better, since it is an attempt to switch expenditure from goods produced abroad to domestically produced goods. Whereas having a recession is a way of killing the expenditure altogether. There is some danger that depreciation of the currency might lead to inflation, but not necessar-

New York campaign chairman John K. Castle, '63 (left), with Glenn P. Strehle, '58 . . . Karen Arenson, '70 . . . Raymond S. Stata, '57 (left), with Michael Schiller, '56.

ily—I think there's a lot of misleading stuff spoken about that issue.

In the long run, the balance of payments situation looks different. Our standard of living in the United States grows mainly with our own domestic productivity. The only other way to boost our standard of living is to keep borrowing abroad. Well, that's what we've been doing for the past half a dozen or so years in this country. We have been absorbing five percent more goods and services than we've been producing and financing that by borrowing from foreigners. A state of affairs like that is not viable permanently.

The more rapidly we can increase our own productivity as a national economy, the less painful will be the process of going from our present import surplus toward the export surplus that we need. One way or the other, either by impoverishing ourselves or by becoming more productive, we will have to generate an export surplus.

Balancing one's trade is no trick at all. Most countries in the world balance their trade because they are so poor and have such poor prospects that no one will lend to them. That's not, as you can imagine, an optimal way for us to proceed. But unfortunately there's no practical short-run way to achieve more rapid increase in productivity.

Remember I began by saying that here I am, a guy who made what reputation he has working on long-run problems in economics. Suddenly I'm having Andy Warhol's "fifteen minutes of fame," and everybody wants to talk to me about what happened in the market yesterday, or better still, what will happen tomorrow. Well, I'm going to persist in talking long-run.

We tend to forget that we have to take action to preserve our standard of living. I was a proponent of growthmanship when it was not fashionable in the United States, because I've learned over the years that it's much easier to have a humane society and to protect the weak when it can be done out of new resources rather than by redistributing fixed resources. I think the history of the last few years has confirmed that. It is slow growth or stagnation that has made us be more unkind to one another as we go along.

My own first research interest in economics was trying to understand what governs long-term growth in capitalist, industrial economies, and that's what interests me now. Since this is a meeting of friends of M.I.T. on behalf of M.I.T., I want to end by speaking up a little bit for my employer. Not out of self-interest—I'm going to retire in a few years and nothing that happens as a result of this campaign will do me any good—but actually out of gratitude.

I won't go so far as to say that what's good for M.I.T. is good for the country; someone tried that once and it fell with a thud. But I do have to say that anyone who cares about the long run has to recognize what I spent my younger years as an assistant professor trying to work out: the major source of economic growth in modern industrial economies is the advance of knowledge, the sort of thing that M.I.T. does and that M.I.T.-trained people do. The fact of the matter is that even if we see to it that our scientific and technological establishment flourishes, we might still screw up the growth of the economy. But if we don't look after the advance of knowledge, if our focus is too short-run, then the chances are that there won't be much left to screw up. □

Reporting, Recognition, Looking Ahead

Seizing a New Opportunity to Serve M.I.T.

It's a tough assignment—cultivate the enthusiasm of 300 alumni on the Saturday morning after a campaign-sponsored black-tie dinner dance for which Du Pont Gymnasium had been transformed into an exotic forested ballroom. But in his first major appearance as president of the M.I.T. Alumni Association, Raymond S. Stata, '57, was clearly up for it.

With campaign planning completed, he told the 1987 National Alumni Conference (NAC) on October 24, the Alumni Association has an unparalleled opportunity to serve the Institute. "The importance of alumni relations has permeated M.I.T. as never before."

The challenge, said Stata, is to maintain existing activities while developing at least three new initiatives:

■ Gain more involvement by younger alumni and students in Alumni Association programs supporting M.I.T. Stata noted that half of all Institute alumni have been graduated since 1965, and "assuring M.I.T.'s future greatness" will soon be their responsibility.

■ Seek new channels for involving older alumni whose activity is now limited. For example, said Stata, give new emphasis to groupings based on courses and departments to supplement those based on classes.

■ Emphasize for Alumni Association staff members—now more than 100 in number—their roles as teachers. The primary assignment for the staff, says Stata, should be to help alumni become more effective in their work for M.I.T.

As to the *Campaign for the future*, Stata assured the alumni of his commitment and that of the Alumni Association. "M.I.T. is not a rich institution by any measure except productivity," he said. "I am amazed at the penny-pinching that goes on in these world-class laboratories.

"There is no major issue before the modern world that is not influenced by work at M.I.T. And with new resources, the Institute can contribute even more in the future than it has in the past."

Toward a $20 Million Alumni Fund

Reporting as chairman of the Alumni Fund Board, Harris Weinstein, '56, pledged the Fund's support to this purpose. The 1987 Fund had made a good start, he reported—a record total of $13.7 million, a 12.5 percent compounded growth rate in the five years since 1982, when Fund giving was $7.7 million. By the end of the campaign in June 1992, however, annual giving through the Fund is targeted to be $20 million.

Awards For Service and Commitment

At the traditional NAC awards luncheon, Stata announced the 1987 awards to individuals and organizations for their services to M.I.T.

Bronze Beaver Awards, the highest recognition the Alumni Association can bestow on individuals, were announced for:

■ W. Gerald Austen, '51, for "significant gifts of time, energy, service, and wisdom to the M.I.T. community through membership on the Corporation, visiting committees, and national committees of the Alumni Association."

■ Susan L. Kannenberg, '61, for her "significant and positive impact on both people and programs, particularly in the area of women's activities."

■ Joseph F. Keithley, '37, "a gracious man whose deep caring for M.I.T. is as clearly evidenced by his commitment of time and energy as by his generosity."

■ Charles E. Kolb, Jr., '67, honored for "the depth and breadth . . . of his extensive and diverse volunteer service to the Alumni Association and the Institute."

■ John S. Reed, '61, who, despite "major corporate responsibilities, nevertheless consistently makes time for . . . supporting M.I.T. in a variety of leadership roles."

■ Emily V. Wade, '45: "She has given an enormous amount of her many volunteer commitments to M.I.T., where she invariably serves with distinction, grace, wisdom, and wit."

Presidential Citations were given to representatives of five alumni organizations that made "outstanding contributions" to M.I.T. during 1986-87:

■ The Boston Seminar Series, "for illuminating our dim understanding of the . . . delicate interplay of philosophies and politics in Africa."

■ The M.I.T. Club of Switzerland, for "consistently demonstrating outstanding volunteer leadership and strong support for the Institute and the Alumni Association."

■ The Enterprise Forum of Texas, for its 1986 Economic Development Symposium that "allowed an important message about the ingredients of the 'Massachusetts miracle' to be delivered to the Houston community."

■ The Class of 1961, for "the most successful 25th reunion ever."

■ The M.I.T. Club of Northern California, for "sustained excellence in offering quality programming . . . (and) providing an exemplary role model for other M.I.T. organizations."

Also announced at the luncheon were six George B. Morgan Awards for outstanding service to M.I.T. through the Educational Council: Eugene Ashley, '48, Burlington, Vt.; Arthur A. Katz, '61, Westchester County, N.Y.; Samuel J. Losh, '54, Los Angeles; James Mcguire, '38, St. Louis; George Revell, S.M.'35, Cornwall, Ontario; and Donald B. Steig, '55, northern New Jersey.

Finally, for outstanding service to the Alumni Association there were ten Harold E. Lobdell, '17, Distinguished Service Awards: Karen H. Arenson, '70; Elda Chisholm, '49; Jorge Diaz Padilla G, Ph.D.'74; John A. Hrones, '34; Shirley A. Jackson, '68; Stanislav Jakuba, S.M.'70; John W. Kunstadter, '49; E. Hibbard Summersgill, '36 (posthumous); Barry Unger, '69; and Bennett M. Zarren, '61. □

Setting Our Sights on $20 Million

By Harris Weinstein, '56

In 1987, for the 13th straight year, the Alumni Fund set a record: nearly 28,000 alumni gave a total of $13.7 million between July 1, 1986 and June 30, 1987.

Many things came together to produce this result. Our staff, our volunteers, and our programs were in place and poised to take advantage of unexpectedly propitious circumstances: a rising stock market and solid economic conditions coincided with changes in tax law that enhanced donations during the Fund's 1987 year.

We count in the Fund all gifts from living alumni/alumnae up to a maximum of $50,000 per year. Total alumni/alumnae giving actually exceeds the Alumni Fund; in fiscal 1987, for example, it reached $35.6 million.

The Alumni Fund has shown great progress over the last eight years in total dollars raised, annual growth, and number of donors. M.I.T., with gifts coming from 48 percent of the undergraduate alumni and 31 percent of the graduate alumni, is one of the leaders in terms of the percentage of graduates who make contributions.

We expect to increase the total number of donors to 30,000 before the end of the *Campaign for the future* in 1992, and over the long term we hope to secure annual gifts from 50 percent of undergraduate alumni and 33 percent of graduate alumni.

As you scan the accompanying donor and dollar history charts, you will see that in recent years the number of dollars received has gone up much more rapidly than the number of gifts. As this implies, many individual donors have increased the size of their annual gifts.

How do M.I.T. alumni/alumnae rank in their support of their alma mater? As we compare our Alumni Fund to the annual funds of other "major league" university fundraisers—the Ivy League schools and Stanford—we see that we are by most measures close to the top but are not yet there.

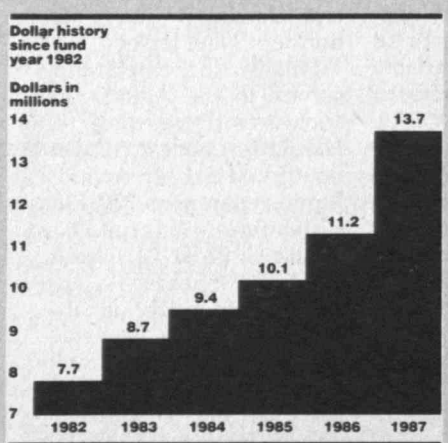
However, the M.I.T. Alumni Fund has grown faster than the annual funds at all other schools save Harvard—with its 225-year head start—and we believe that we can do still better. By the end of the campaign in 1992, we intend to raise the median gift from $50 to $100 and the total amount raised annually to more than $20 million. We must reach these goals if we are to succeed in meeting the Fund's assignment of raising $100 million toward the campaign.

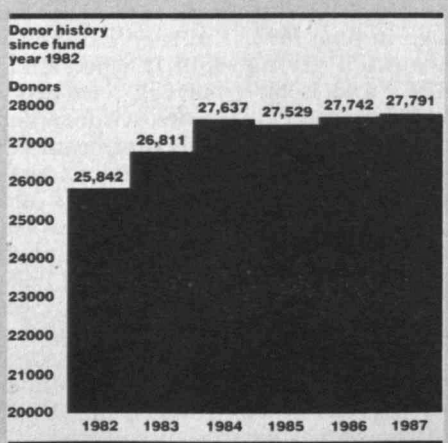
The Alumni Fund Board believes that we can present a strong case to donors for upgrading their annual gifts.

In 1987, 62 percent of the donations received were under $100. While we should encourage younger alumni who are still continuing their studies to make whatever gifts they can manage, we need to convince regularly employed alumni that a $100 gift is the least they should consider, and that most could and should give more. After all, $100 represents little more than the cost of dinner for two followed by theater or a sporting event in most metropolitan areas today.

We must ask for appropriate amounts and explain our case well. We need to communicate three vital facts to fellow alumni: first is the cost of a year's education at M.I.T.; second is the enormous amount of money that M.I.T. requires to supplement tuition charges and to provide undergraduate financial aid and graduate student support (*see charts*); and third is the extent to which every one of us received a subsidy from our predecessors—a gift worth as much or more than the tuition we paid. Few of us can say we have repaid that debt.

Let me elaborate on the concept of a subsidy. We all received a subsidy because the annual tuition has always been much less than M.I.T.'s cost. To appreciate the value of the support we received, look at the top part of the bar on the "cost vs. tuition" chart closest to the time you were at M.I.T. Multiply that amount by the number of years you attended M.I.T. If you add compound interest of eight percent (modest for these purposes) and the 1960 bar as a base,





Dollar distribution by gift range

Range	1975	1979	1983	1987
$1–24	47%	29%	23%	7%
$25–49	28%	33%	29%	32%
$50–99	12%	19%	21%	24%
$100–249	9%	14%	17%	22%
$250–999	2%	3%	7%	11%
$1,000–4,999	1%	2%	2%	3%
$5,000–up	0%	1%	1%	1%
Total number of donors	21,361	21,602	26,811	27,791

CHARTS: TOM BRIGGS, INC.

We should be working toward a median gift of $100—that's not much more than the cost of dinner and theater for two in most cities.

the 1987 value of the subsidy received by a 1960s graduate is nearly $100,000. For 1950, the figure is $45,000; and for 1970, the figure is nearly over $45,000 and growing rapidly.

Such numbers emphasize how much we need to give to M.I.T. before we can say that we have done for our successors what our predecessors did for us. If Alumni Fund volunteers and staff can deliver this message to our fellow alumni, we will raise our $100 million and more.

The Fund is strengthening staff and programs across the board, but two efforts are particularly important to the *Campaign for the future*. These are an enlarged and more sophisticated reunion gift effort, plus personal visits to virtually every alumnus or alumna who has contributed $250 or more in some year—to encourage these donors to upgrade their gifts.

Historically, reunion gifts were not solicited until the 25th reunion. Later reunion gifts were sought only at the 40th and 50th anniversaries. There are now highly successful 60th and 65th reunion gift efforts; there have been modest fifth and 10th reunion gifts in recent years; and 1987 was the first year in which we sought a 15th reunion gift.

We cannot rely exclusively on reunion gifts, because the alumni body has not been solely organized around classes in the past. But we do think there is considerable unrealized potential in the reunion gift program. Even as matters now stand, reunions contribute significantly to our results. Of the $13.7 million raised in fiscal 1987, at least one third was reunion-related.

The Fund is working toward a time when every fifth year reunion includes participation in the Institute's fundraising program. Through an enlarged reunion gift staff, the Alumni Association is providing increased support to each reunion gift committee, and we are trying to organize the gift committees at an earlier date. We are also seeking ways to utilize reunion gift committee members between reunions, so that we continue to capitalize on the skills and momentum they develop during the fundraising period.

The Alumni Fund is also trying to enhance the concept of class-based fundraising in additional ways. One approach is to emphasize the importance of a senior gift. The class of 1987 responded with pledges or gifts from 38 percent of its members for a total of about $35,000. This sum represents a significant financial commitment to M.I.T., because it is paid at a time when most young graduates are still continuing their educations.

We are also planning to revitalize the class agent program. Most classes have always had agents, but we have not had the resources to make consistently effective use of them. We must and will provide them with better support.

The Alumni Fund's campaign-driven personal solicitation program is particularly ambitious. We intend to ask each of the nearly 1,000 solicitors to call on two to five fellow alumni to solicit five-year pledges of $5,000 or more. This effort will consist of 54 separate drives in 35 areas throughout the United States.

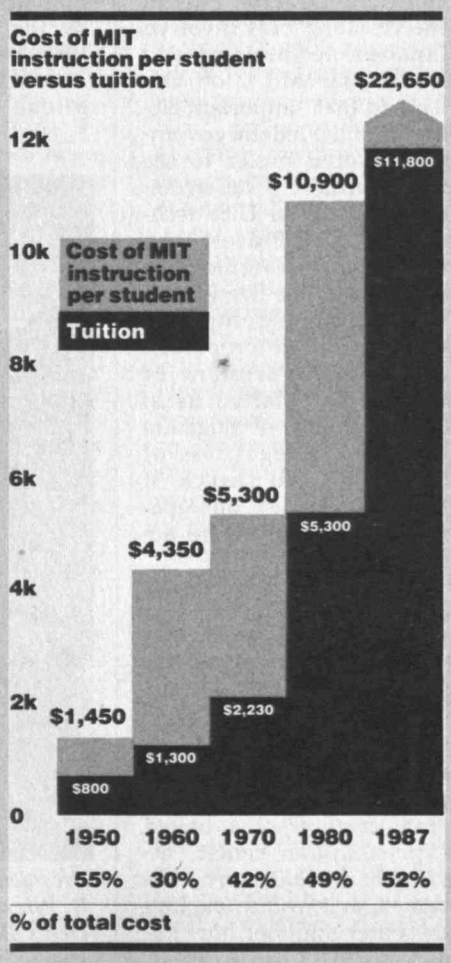
In each drive, 10 to 25 alumni solicitors will work over a 12-month period. We hope that the program will contribute $7 to $10 million in increased gifts to the Fund. And we hope that the result will be to convince alumni/alumnae to make larger annual gifts during and after the Campaign.

Over the course of the Campaign, we will call upon many alumni to help. We know that you will respond as in the past—giving generously of time and funds. □

HARRIS WEINSTEIN, '56, is chairman of the Alumni Fund Board.

Undergraduate budget and financial aid

Typical Student Budget 1987–1988:	
Tuition and Fees	$12,500
Room and Board	4,470
Books and Supplies	480
Personal Expenses	1,150
Average Travel Expenses	250
Total	**$18,850**
Meeting a Typical Student Budget 1987–1988:	
Typical Family Contribution	
Parent's Contribution	$ 5,300
Summer Earnings	1,200
Student Assets	100
Sub-Total	**$ 6,600**
Typical Student Financial Aid Package	
Self-Help (loan and/or part-time job)	$ 4,900
Grant	7,350
Sub-Total	**$12,250**
Total	**$18,850**



UNDER THE DOMES

New Plans On Computer

Plans for M.I.T. to acquire a supercomputer for use in science and engineering research were set aside late last fall, to be replaced by a new program now being studied that would place the Institute "at the outer limits of the technology."

More than a year ago M.I.T. solicited supercomputer proposals from five computermakers. Two of the resulting bids involved Japanese technology, and late last fall M.I.T. officials learned that "important elements of the federal government would prefer to see M.I.T. acquire a supercomputer based on U.S. technology," said Provost John M. Deutch, '61. At the same time, two of the five would-be supercomputer suppliers withdrew their proposals, and the Department of Commerce "alerted us to the possibility of litigation based on allegations of dumping," said Deutch, if computers based on Japanese technology were acquired.

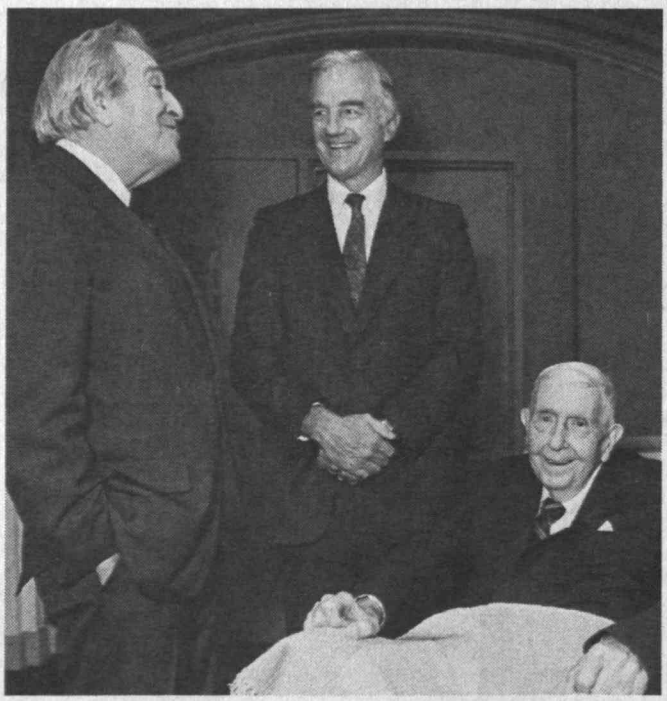
In the face of these developments, and for reasons that were advocated even while the supercomputer proposals were being solicited, M.I.T. has now turned to what Deutch calls "a much more ambitious proposal." The proposal suggests creation of a linked supercomputer center, involving at least two machines, that would "explore the outer limits of how supercomputers can work together to address fundamental problems in the physical sciences and engineering.

"Our conversations with many computer scientists, industry experts, and government officials lead us to speculate that the time may be ripe for such a university-industry collaborative undertaking," said Deutch.

The five companies that had been vying for the supercomputer sale to M.I.T. were Honeywell-NEC, IBM, Cray, Control Data, and a joint venture of Amdahl and Fujitsu. Observers quoted by the *Boston Globe's* John Wilke saw M.I.T.'s withdrawal as a setback for Japanese supercomputer vendors in their efforts—thus far largely unsuccessful—to penetrate the U.S. market. □

Dana Award to Killian

If I could recount for you the history of science and technology in this century—their impact on education, communications, defense, economic development, and every vital area of our national life—you might have a fitting introduction to the role and achievements of James R. Killian, Jr.



President Emeritus Jerome B. Wiesner and President Derek Bok of Harvard shared an extraordinary Dana Foundation honor to James R. Killian, Jr. '26 (right), in New York late last year.

That accolade was the introduction given Killian by David Mahoney, chairman of the Charles A. Dana Foundation, in presenting him for a Special Dana Award in New York late last year. The award citation termed Killian "an educator who has influenced generations of scientists and engineers and, indeed, U.S. presidents, in the interest of world security and human welfare."

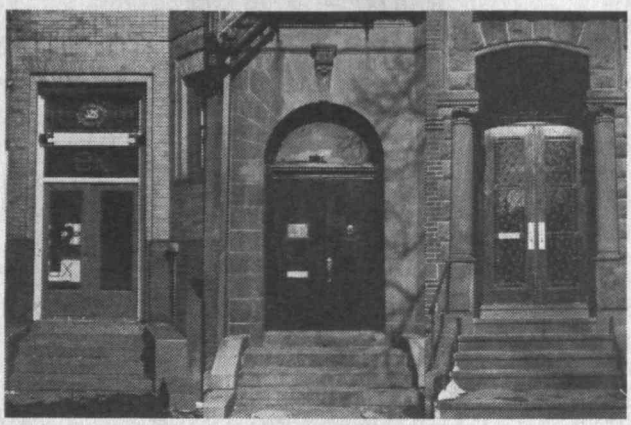
Receiving the award in New York, Killian was accompanied by his daughter and grandchildren. The $25,000 honorarium was contributed by the Dana Foundation at his request to M.I.T. Killian, who graduated from the Institute in the class of 1926, was president from 1949 to 1959 and then chairman of the Corporation until 1971. He was called to Washington in 1959 by President Dwight D. Eisenhower to become the first White House science adviser. □

Fraternities: Two Few Men

As the number of women increases—up to 37 percent last year and this year—the number of men in M.I.T.'s freshman classes is falling. One result is serious financial problems for the fraternity system.

Of 420 vacancies in the independent living groups in September, only 350 were filled by members of the Class of 1991, leaving the largest number of empty

PHOTO: SCOTT MCKIERNAN, DANA FOUNDATION



Their classic facades hide a new dilemma for M.I.T. fraternities. As more women enter the Institute, all-male fraternities must pledge an increasing proportion of the undergraduate men.

beds in recent years. The figures were reported to *The Tech* by Paul W. Parfomak,'88, chairman of the Interfraternity Council.

The pressure falls heavily on the all-male fraternities, which must collectively pledge far more than the traditional 50 percent of the men in the freshman class to fill their empty beds. "Some houses can take the loss of a few people and survive indefinitely," Parfomak told *The Tech*. "But other houses are having a difficult time adjusting." For this and other reasons, five fraternities have opted out of their national organizations during the past decade to become unaffiliated living groups, most of them co-ed.

Anuradha Vedantham, '90, said in her report for *The Tech* that "there is little significant difference in the cost of living in dormitories and independent living groups." But a shortfall in residents would soon drive up costs in the latter, she says, possibly triggering what Parfomak described as "a vicious cycle of ever-increasing vacancies."

M.I.T. vs. Homeless?

Ever since M.I.T. began assembling property northwest of the campus in the early 1970s, the so-called "Simplex site" has been a magnet for controversy. It consists chiefly of 19 acres acquired by M.I.T. from the Simplex Wire and Cable Corp. when the latter moved to Maine; later acquisitions have brought the site to a total of some 25 acres.

Dissident residents of the adjacent Cambridgeport area have never accepted M.I.T.'s goals for redevelopment; they demanded more low-income housing and "blue-collar industry" than the Institute believed was economically viable. The issues have been argued in Cambridge city agencies for nearly 20 years—and taken to the streets and the press by Cambridgeport demonstrators and sympathizers for nearly as long.

Now M.I.T. and its developer are negotiating final approval from the City of Cambridge for a retail, office, R and D, and residential complex to be called University Park. Some of those who object to the development are trying to stall it by linking it to the plight of the homeless in the greater Boston area.

Last fall, a dissident group calling itself the Simplex Steering Committee placed a number of tents on the property to house a weekend "live-in" protest. Homeless people were invited to share the hospitality of "tent city," and a number of them remained on the site in cardboard and canvas shelters after the protest was over.

Thus began a confrontation that seemed to pit M.I.T. against the homeless, who then demanded access to—and presently ownership of—three dilapidated houses on the site. The structures, vacant for several years, have been the subject of a complex negotiation with the Cambridge Rent Control Board for their removal.

A small group of homeless and M.I.T. students staged a "sleep-in" in Lobby 7 to support the protest.

As tension increased, and the tent city stayed on, there were growing complaints from neighbors and tent city residents about violence. Finally, late in November, 33 days after the first live-in protest, with winter's first bitter weather forecast, the squatters were removed by Cambridge and M.I.T. Police. The police action was not violent—contrary to a report in the *New York Times*, police dogs were not used. But tempers flared and arrests on charges of trespassing were made. Most of those arrested were supporters and activists, not the homeless.

As this issue goes to press, the charges remain to be heard in court, and the homeless have found accommodations—some in Cambridge shelters, some with friends. A few accepted M.I.T.'s offer of motel housing for the several cold nights of November immediately after their departure from tent city.

M.I.T. remains committed to work as part of a broad public-private initiative to assure shelter for the homeless in Cambridge, according to Walter L. Milne, assistant to the chairman of the Corporation and the president. Milne notes, for example, that nearly a decade ago the Institute joined with others to place on M.I.T. property, leased for $1 a year, the largest homeless shelter now operating in Cambridge.

Furthermore, University Park is planned to include "a substantial amount of new housing," some designated for low and moderate income tenants, says Milne. The first new housing—more than 100 units—will be created by the renovation of an existing building on which work is due to begin by mid-1988.

Milne emphasizes that Cambridge city agencies "are the proper forums for the development, review, and resolution of the many complicated issues that are bound up in the University Park project.

There should be little room in Cambridge," he says, "for direct-action tactics and extra-legal strategies, and no room at all for those that use, and use badly, such a vulnerable group as the homeless." □

PHOTOS: RALPH SANTOS, '92, FROM TECHNIQUE

CLASS NOTES

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We're happy to bring you these excerpts from a recent letter from **Elbridge "Elly" Devine**: "I will be 95 next July; therefore all my classmates will be in that range. I have lived in the same house since 1923. I have had two sons and one daughter, 13 grandchildren, and nine great grandchildren. We still remain pretty much together. I am often asked, 'How come you have lived so long?' Well, some of my ancestors had long lives. I love to be outdoors, and every year I plant some flowers and vegetables. The activity helps keep me in good shape, I think. In 1960 I had angina, but it is still controlled with 'nitro' pills. May God still stay with me. I still mostly take care of myself, for which I am lucky. This past summer my garden was very good, and I supplied the neighbors with vegetables. Next summer I hope to do the same. I dread the winters and hope I can survive the cold."

And this portion of a recent letter from **Charles "Mac" McCarthy**: "I am in reasonably good health but slowed down by a stroke which put me in the hospital for a while. I have lost all contact with my classmates and would be glad to learn how they are doing." . . . **Will (Wilfred) Wylde** writes, "I was not able to come to any meetings at graduation time this summer. I do get to a Wylde family reunion in and around North Adams, in the Northwest corner of Massachusetts, but that has to be on the fourth Saturday in August. There were three of us Wyldes at M.I.T.: Harry, '14, now deceased; and Edward, '21, now living in Naples, Fla., the fall, winter and spring but in a cabin on a lake near Cambridge, N.Y., in the summer. I still receive the M.I.T. magazine and always look for 1916 news. But I am sorry that I cannot give you any news from any classmates. I belong to the M.I.T. Club of Southwest Florida which has its headquarters in Sarasota, which is about ten miles south of where I live, but I only get to meetings about once a year. I am the oldest member I believe and also of the oldest class. I live in the Shores, a retirement home and am very comfortable and well cared for by my wonderful wife, Donnie, and the many helpers in this home."

It's great to hear from Elly, Mac and Will, and to know that they are doing so well. Let's hear from more of you. Share your news with us. You are very special to your classmates.
—**Bob O'Brien**, Acting Secretary, 25 Keith Rd., Pocasset, MA 02559

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This month's class news is all one-sided: no letter or even postcards from classmates sharing their recent celebrations and family or hobby satisfactions. Please do write!

So in the meantime this month we can only report the sad news—the passing of classmates whose companionship was enjoyed starting more than 70 years ago.

In September we lost **Tubby Strout** —I say Tubby, for all these years we've known him by that nickname. Maybe many of you had even forgotten his real name: Henry E. Besides being one of our most loyal members of the class, Tubby was an extremely active Mason. He kept close affiliation with his fraternity of which he was its alumni president for five years. He rarely missed a class function of any kind.

During World War I he served in Europe as captain in the Engineer Corps. His professional life was sales manager, at times on the West Coast, but primarily in New England. After retiring he lived in Amherst, N.H., then Osterville, Mass., and finally Lawrence, Kans., where one of his two daughters resided.

We now have more information about **Warren Tapley**, whose death was reported in the October issue. He was born and raised in Newton and spent the last 63 years in Falmouth. For years an executive of Stetson Shoe Co., he was a sales executive for New England Container up to his retirement 30 years ago. He served in World War I (2nd lieutenant). We hear that not only was he a repeated winner of the Senior Golf Championship at Woods Hole Golf Club but that he was playing golf right up to summer before last.

Herbert Dimlich, who started in our class but then graduated from Boston University, died last July 9 in Pawtucket. Herbert devoted a lifetime to teaching, first in Shelburne, Mass., then in Pawtucket, where he was head of West High School Mathematics Department upon his retirement in 1965.—Written for the secretary by **Don Severence,** 39 Hampshire Rd., Wellesley Hills, MA 02181

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The most exciting news for this issue comes from the M.I.T. campaign kickoff dinner for approximately 400 campaign workers last October 22 at Walker Memorial. M.I.T.'s goal is to raise $550 million.

As part of the program, several alumni spoke, and I was selected to represent the oldest graduates. My message to the volunteers stressed the importance of education and, in particular, research in science and technology in order to maintain and continue the advance in our standard of living.

In reply to my recent letter to **Ted Braaten,** he is looking forward to our 70th reunion in June 1988. I will appreciate similar notes from many of you. . . . **Herb Larner** sent me copies of his interesting correspondence with Surgeon General Everett Koop with reference to the disease AIDS in Africa.

We note the death of **George Woodruff** on February 4, 1987, in Atlanta, Ga. Your secretary had considerable correspondence with him in recent years. He has been very active in community affairs in Atlanta.—**Max Seltzer,** Secretary, 865 Central Ave., Needham, MA 02192; **Leonard I. Levine,** Assistant Secretary, 519 Washington St., Brookline, MA 02146

CAMPAIGN
The Kick-off

Max Seltzer, '18, was one of several speakers representing the alumni body at the formal dinner that kicked off the* Campaign for the future *last October 22. When Max came to M.I.T. in 1914, he remembers that people worked 60-hour weeks with no vacations and no social security. Sanitation was poor, laundry was done by hand, and travel more than 25 miles from home was rare. Max contrasted that picture with life today and credited the change to American emphasis on education and, in particular, on research in science and technology. "In this accomplishment, M.I.T. takes second place to none," he said.

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In last months' *Review*, I mentioned the deaths during the past year of two more of our classmates. First was **Arthur C. Kenison.** The report on Arthur came from his wife in Northville, Mich., and told of their happy marriage for many years. He had a very active career. Then there was the death of **James M. Stang,** M.D., who in addition to his period at M.I.T. studied medicine at the Harvard Medical School and became a practicing physician. He had a full-life medical career in West Penn Hospital. Several of our classmates similarly devoted their careers, with credit, to medicine. We recall both of these men as undergraduates and regret their passing.

We continue our report with good news. We have no deaths to report this time. We had a very nice letter from **Doc Flynn,** who writes interestingly of his overcoming the obstacles of old age and making the best of his life. He enjoys reading the class notes. We also had a nice note from **Bob MacMullin** who is now deaf and blind. He recalled our class song, "When Good Friends Get Together."

I am practically as blind as Bob, but with the help of my good wife Florence, I am able to get

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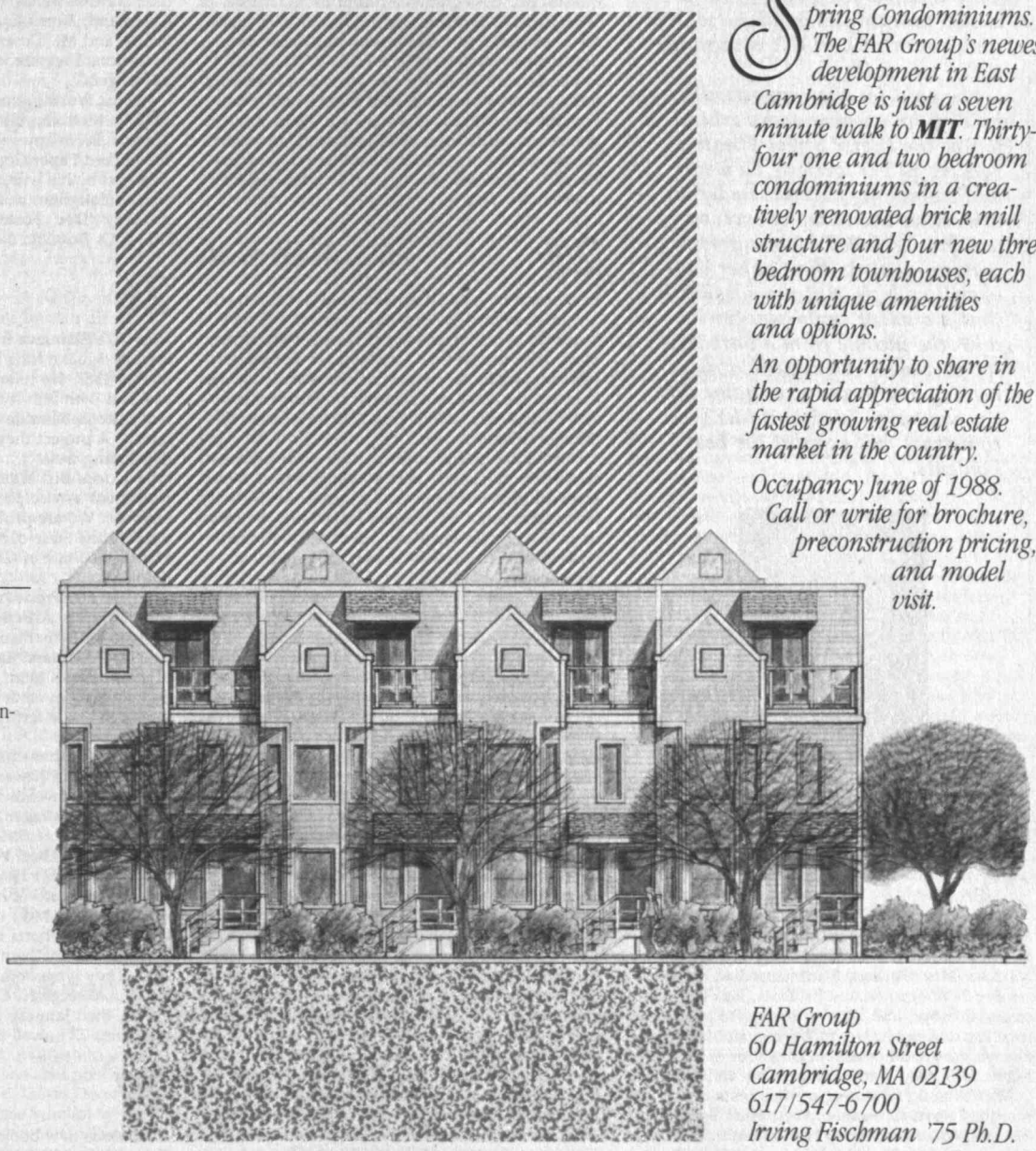

Spring Condominiums. The FAR Group's newest development in East Cambridge is just a seven minute walk to ***MIT****. Thirty-four one and two bedroom condominiums in a creatively renovated brick mill structure and four new three bedroom townhouses, each with unique amenities and options.*

An opportunity to share in the rapid appreciation of the fastest growing real estate market in the country.

Occupancy June of 1988. Call or write for brochure, preconstruction pricing, and model visit.

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The FAR Group, active in Cambridge real estate since 1979, won the coveted award for ***Design Excellence in Housing*** in 1985; given biannually by the Boston Society of Architects.

FAR Group
60 Hamilton Street
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Irving Fischman '75 Ph.D.

CAMPAIGN
The Kick-off

Marjorie Pierce, '22, addressed guests at the launching of the* Campaign for the future *in October. She applied for admission to M.I.T., she said, not because she had any visions of being a great architect, or "a second Madame Curie," but because she believed that with an M.I.T. degree she would always be able to get a job. It was a faith well-founded, for more than 70 years later, Marjorie is still working as an architect. "I can never thank M.I.T. enough for that," she said.

She paid for that opportunity by holding an evening and weekend job at the Exeter Street Theatre, earning $7 per week as an usher while studying calculus under an exit light. The value of such an education—enjoyed by many more women students than in her day—is still as high. But the possibility that a student could pay for it with the income from a part-time job is almost nonexistent today, leading Marjorie to her point that the campaign is vital if M.I.T. is to attract and support the best students.

these notes to you.—**W. O. Langille,** Secretary, P.O. Box 144, Gladstone, NJ 07934

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Not much news this month. I received a letter from Claudia (Mrs. **Josiah) Crosby** telling me that Mildred (Mrs. **Herbert) Kaufmann** died on September 24 at her home in Sarasota, Fla. The Kaufmans, Crosbys, and Haywards used to get together during winters in Florida, and Millie was always the good hostess on occasions in their home. Our deep sympathy goes out to Herb.

The Alumni Office sent me two obits this month: **Everett A. Soars** of West Palm Beach, Fla., who died on May 4, 1987 and **Winfred L. Foss** of Hopkinton, N.H., on August 2, 1987. Foss was a World War I army veteran and a part owner of the Pierce Arrow Co. in New Haven and also in Baltimore, Md. He served as industrial director for the State of New Hampshire under Governor Sherman Adams.—**Sumner Hayward,** Secretary, Wellspring House E64, Wash. Ave. Ext., Albany, NY 11203; **Samuel E. Lunden,** Assistant Secretary, 6205 Via Colinita, Rancho Palos Verdes, CA 90274

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News is at a low ebb as I write this in mid November. Had a telephone conversation recently with class president **Parke Appel**. He reports all in good order in his area. . . . **Abbott Johnson** has retreated to Phoenix for the winter after his customary summer in northwest Michigan. . . . **Hall Baker** and **Walt Saunders**, of whom I have heard recently, remain in good health while continuing to reside in their homes in Cape Elizabeth, Maine.

Winter plans for your secretary and Ruth remain uncertain, but if we go away at all, it will more likely be to Bermuda than Florida. Travel seems more of a chore now than it used to.

Percy Bruce Bass, age 89, died September 25, 1987, at the Jupiter Convalescent Pavillion in Tequesta, Fla. Bass graduated from the University of Virginia in 1920 before coming to M.I.T. to graduate with a master's degree with our class. He was division supervisor of Electrical Distribution for Public Service Utilities for 45 years before retiring to Tequesta 17 years ago. He is survived by his wife Marion (Engel), one son, two daughters, two grandsons, and seven great-grandchildren. Our regrets are extended to the Bass fmily.—**Yardley Chittick**, Secretary, Rt. 1, Box 390, Ossipee, NH 03864

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65th Reunion

In accordance with **Earle Griswold**'s will, American International College has received a $5-million bequest, and Wing Memorial Hospital of Palmer, Mass., has received $1.3 million. He also made substantial gifts to the Boy Scouts of America. He founded the Earle A. Griswold professorship at M.I.T., and David Botstein has been selected as the first holder.

Harold Townsend died on June 3. He graduated with our class in electrical engineering. After graduation, he became chief engineer for Oldbury Electrochemical Co., Niagara Falls, N.Y. We have no other information about his career.—**Richard H. Frazier**, Secretary/Treasurer, 7 Summit Ave., Winchester, MA 01890

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Russ Ambach is slowly recovering from his heart attack but feels very handicapped by his dependency on a cane for walking. As class secretary, he is continuing his long service, since early 1971, of keeping alumni and alumnae informed. Russ advises that **Ed Abdun-Nur** did arrive in Boston as planned, partly for medical treatment he was seeking but more newsworthy was his visit to the Institute to set up an Abjun-Nur Scholarship fund. Ed joined Russ, **Ray Leher**, and **Bob Fife** in further planning for our 65th reunion, and they made some reservations at the Hotel Sonesta in Cambridge, where we were on our 60th.

James H. Grahame passed away on October 25, 1987. He was born in Manitoba, Canada, in 1895 and had a year at the University of Manitoba before coming to M.I.T. for a degree in chemical engineering, followed by getting his LL.B. at St. Lawrence University. All of that was preceded by three years in the Canadian Army and the Royal Air Force with distinction. His business career was with the Texaco, Inc.'s predecessor in New York in research and patents. When he retired in 1958, he was responsible for all general patents. They soon moved to Virginia Beach, Va. and, after ten years, moved to Escondido in southern California. He was active in many committees until Alzheimer's disease became serious in his last few years. He is survived by his wife, Marguerite, their son, Richard of Bedford, Va., two grandchildren and two great-grandchildren.

Stanley H. Turner died in early October near his hometown of Harvard Mass., less than 30 miles northwest of M.I.T. He served as treasurer of the town from a year after graduation until a year before our 25th reunion. When he retired in 1965, he was treasurer of the North Middlesex Bank of Ayer, a larger town near his birthplace. He is survived by his wife, Elizabeth, two sons, and three grandchildren.

A little more cheerful news. Your new co-secretary of the class of 1924 was remarried on August 28, 1987, to Katherine H. Dixon of Carmel.—**Rock Hereford**, Co-secretary, Box 5397, #90, Carmel, CA 93921; **Russ Ambach**, Secretary, 216 St. Paul St., Brookline, MA 02164

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Don Taber and Evelyn enjoyed an interesting trip this past summer. They flew to Iceland and, after two days of sightseeing, boarded the *World Discover* for two weeks visiting Westland Islands, Greenland, Newfoundland, Saint Pierre, Nova Scotia, and Mt. Desert Island, Maine, ending up in Boston. They ate well with seven chefs for 52 passengers.

Arthur Worthington died on September 18, 1987, in Methuen, Mass., at his home on Emsley Terrace. For many years, Art was a chemist with the Oxford Paper Co. of Lawrence, Mass. He is survived by his wife, Elinor H. (Newman), three sons, a daughter, and seven grandsons.—**F. Leroy "Doc" Foster**, Secretary, 434 Old Comers Rd., P.O. Box 331, North Chatham, MA 02650

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Juan T. Villanueva from Guinebatan, Albay, Philippines wrote a long letter to **Bill Meehan** in September 1987. He refers to an October 1984 visit he had had with Bill. It was a "never-to-be-forgotten" automobile ride and he was lavishly entertained. A project they discussed regarding rope is developing well. . . . It was a great loss to the class to lose **Bill Meehan**. His performance after retirement as vice-president of A&P Grocery was fantastic. We are proud of his work as an engineer for the State of Mass., the University of Mass., the State of Conn., and the Rockefeller Foundation.

The M.I.T. President's Fund has received a contribution from **Alberte Ortenblad** of Brazil to provide more mathematics in all engineering courses." He must have realized the application of mathematics to an outstanding career in building, 43 years in cattle breeding, turning garbage into high grade fertilizer, and rubber tree productivity research.

Mary and I have just returned from two weeks in October and November in the Alps of Europe. We had great weather and wonderful tours.

John M. Whitaker of Huntington, N.Y., died April 2, 1987. . . . Wife Jeanne reports the death of Professor **Robert W. Dresser** of Trumbull, Conn., on March 15, 1987. . . . Daughter, Nancy, reports the death of her father **Henry B. Waterman** of Bowie, Md., on September 4, 1987. . . . Wife, Mone, reports the death of **Edward B. Stallman** of Chatham, N.J. on September 25, 1987. They were both with us for our 60th reunion. . . . **George H. Craemer** of West Hartford, Conn., died January 12, 1987.—**Donald S. Cunningham**, 27 Lowell St., Braintree, MA 02184

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A fabulous new book *Stopping Time* contains 138 illustrations with 22 plates in full color of "Doc" **Harold Edgerton**'s instantaneous wonders since his 1933 invention of the strobe.

The authors are Estelle Jussim, a leading writer and lecturer on photography and Gus Kayafas, '69, a research affiliate in the M.I.T. stroboscobic light laboratory. He is also the founder of Palm Press that specializes in printing fine photography. A treasure.

Selim Oscar (Quincy) Lunden of West Hartford

has written (nearly a year ago) that he retired from the Conn. Dept. of Transportation in 1972 after 42 years of service. In 1967 he was working for their Highway Department as engineer of utilities. He is a member of Conn. Society of Civil Engineers. He and his wife Vivian have been enjoying their life of retirement, furniture repair, coin and stamp collecting. They can boast of three children, seven grandchildren, and one great grandchild. A grandson Paul Lunden graduated from M.I.T. in 1987. He reports his older brother, **Eugene B. Lunden** (also M.I.T. '27) died in Davis, Calif., on October 11, 1986. After a few years with AT&T Co., he was five years with Westover Corp. (land development). Then he became resident engineer on various construction projects for the town of Walpole. After five years of military service, ending as major in transportation, Gene joined Fay, Spofford & Thorndike in Boston as airport designer and engineer where he worked until retirement. He enjoyed photography, hiking, bowling, and skating.

Thanks to **Larry Grew,** we have a sequel story on Dr. **Carl Weis** who died in April 1986. In 1975 fulfilling a life-long dream, he and his wife Alma established the Tale of the Whale Museum above his medical office in a large Greek Revival house, which is part of the "Whaling City's" famed Whale Oil Row in New London. The central focus of the popular museum was a completely outfitted whaleboat from the Charles W. Morgan. Harpoons, lances, scrimshaw, photographs, a maritime library, and manuscripts round out the collections.

After Carl's death, the daily operation of the museum became an impossible burden for Mrs. Weis. She decided, because of their long and happy association with Mystic Seaport, to donate their collection to it. Alma Weis, who is a tireless worker in many organizations, continues to be active and hopes to spend more time at Mystic in the future.

Walter K. Johnson died on September 10, 1987 in Jessup, Md., after a heart attack. After graduation he joined Stone & Webster as hydraulics engineer. In 1935 he joined TVA then went into the Corps of Engineers in 1942. He worked with the Veterans Administration upon leaving the U.S. Army in 1946 as structural engineer. Then in 1951 went over to the new Air Research and Development Command USAF in Baltimore as a structural engineer. He retired from the U.S. Army Reserve as a Major in 1965. In 1970, he retired as a civilian engineer for the Air Systems Command at Andrews Air Force Base after 38 years with the federal government.

Walt was a life member of ASCE and a member of Engineering Society of Baltimore. He was fond of travel, woodworking, and stamp collecting. His widow, Peggy, has written: "Walter tried his hand at everything—painting, marquetry and ceramics to name a few. Our home is filled with his many works of art." Our deep sympathy is given to Peggy and her family.—**Joseph C. Burley,** Secretary, RFD #3, Epping, NH 03042; **Lawrence B. Grew,** Assistant Secretary, 21 Yowago Ave., Branford, CT 06405

28 60th Reunion

Someone knowledgeable once said, "There is only one Jim Donovan." That observation always was and still is most appropriate, but now it must be expressed in the past tense. **James Donovan** died on October 16, 1987. Those who knew Jim can quickly agree that he was an extraordinary man. And there were indeed many who knew him very well; his activities and lifestyle brought him into easy association with people at nearly every level of society.

He was just as ready to help an unknown elderly woman to catch her bus as he was to write a letter of advice to the president of the United States in Washington or to the pope in Rome. A local boys' club had his continuing interest and support. It was not beneath his dignity to step

Jim Donovan

into the street and remove a piece of broken glass and so perhaps spare some unknown motorist a cut tire. Thoughtfulness and sensitivity in relation to others were just normal for him. No social obligation, however slight, was ever left unacknowledged—sometimes with just a one-line note.

Family life in the Donovan household also reflected much of Jim's personality and was nicely complemented by wife Frances and her Radcliffe background. Jim was always quick to praise her and their two sons for their steady support of him. We are most pleased to know that Frannie will continue her relationship with '28.

Perhaps, and especially in our day, some of us as undergraduates knew only a few of our classmates very well, and this limitation may have persisted into our later years. Here again, Jim was different—he was always busy writing, telephoning, or visiting classmates—'28 was very important and dear to him. As a consequence, he probably knew and was known to more '28ers than anyone else in the class. This was one reason we thought it important to send a notice to each of you shortly after his death.

Jim graduated in Course X, chemical engineering, and remained in that profession all his life. For a few years he stayed on at M.I.T. as an assistant under Dr. Warren K. Lewis. The two became lifelong friends. Another lifelong association began when Jim met with **Ralph Jope** on their very first day as M.I.T. freshmen. From then on, they worked together as students, as alumni, and in business until the very day in July, 1965 when Ralph died unexpectedly. Their business was started at the bottom of the Great Depression and survived that ordeal and later crises largely because of the courage, tenacity, honesty, and hard work of those two leaders. The company, Artisan Industries Inc., in Waltham, Mass., continued to grow under Jim's unique (almost fatherly) leadership and now enjoys a wide reputation as a builder of high quality and special chemical engineering equipment. Jim's son, Andrew, has assumed full responsibility for its executive direction.

In just about every area of his interest and participation, Jim became distinguished and honored. He was a fellow of the American Institute of Chemical Engineers and a recipient of its prestigious Founders Award. For many years, he was a member of the Massachusetts Board of Registration of Engineers and of Land Surveyors. His tireless work for our own Alumni Association was recognized even back in 1970 when he was awarded its highest honor, the Bronze Beaver.

No one could have been more dedicated than Jim to the welfare of M.I.T. and the class of 1928. The interest and activity that began when he was a freshman continued to the end of his life. He was always an active class officer and was our class president during all of his last 22 years. We can't replace him, really—there was only one Jim Donovan.—**Walter J. Smith,** Secretary, 37 Dix St., Winchester, MA 01890

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I have a note from **Rolf A. Zurwell** of Forest Hill, Md., which states that he recently celebrated his 81st birthday. "By the grace of God, I am in good physical, mental, and spiritual health. I am active in serving many people in many ways in the name of Jesus, play the piano for one-to-two hours a day and continue to study science in the field of static electricity and gravitation, its sources and new uses. I still continue to serve one client in my business, design of new labor saving devices and other product designs. Greetings and brotherly love to all our classmates." . . . **Jerome Franks** of Cincinnati, Ohio, is enjoying his retirement years with his wife Helen. His hobbies include golf, travel, and reading.

Edward V. Papenfus of Vancouver, B.C. (Canada) writes, "I now am fully retired, but do a little gardening, take daily walks for one hour, and manage investment porfolios for my wife, sons, and myself. We take occasional motor trips, but we have not been overseas for over two years. We will probably spend some time in Hawaii in 1988." . . . **Joseph Green** of Coconut Creek, Fla., writes, "I have lived in Florida for the past 12 years and have visited New England every summer. Have attended all of my high school and M.I.T. reunions. I have been a member of the Fort Lauderdale M.I.T. Club for a number of years and attended the Florida M.I.T. Festival at Cypress Gardens several years ago. Best wishes to all our classmates."

William H. Jones of Sun City, Ariz., writes, "First I want to thank you for all your birthday greetings. I just joined the octogenarian club, being 80 years old, so I thought it was time to send some news. My wife Evelyn and I had our 55th wedding anniversary on July 30, 1986, and we feel most thankful for our many happy years together. We moved from Charlotte, N.C., to Armond Beach, Fla., to Sun City, Ariz., 12 years ago after retirement. I still enjoy my music, golf, and the many activities Sun City affords. Best wishes to all our classmates." . . . **Thomas H. McCue** of Newton Highlands, Mass., writes "I have now completed four courses at Boston College and currently am taking courses in business management and Spanish. I plan to go to South America where the opportunities are great. My hobbies are swimming, visiting local beaches, travel, and research in inventions." Tom also is active in Alumni Fund telephone solicitations to members of all classes, for which he received the Harold L. Lobdell Award last year for his exceptional work. . . . Carmen, wife of **Frederic D. Merrill** of Chatham, N.J., sends a note: "As a follow-up to my last letter that my husband Fred has Parkinson's disease, I now find it necessary to put him in a nursing home. He appreciated receiving your nice birthday greetings, and I hope you will continue sending them to our home, and I will take it over to him when I visit him."

Amasa G. Smith of Birmingham, Ala., writes, "I am still active in several civic organizations and the United Appeal. I have enjoyed the success of the United Speed Food Bank, which we started four years ago, myself as president. It has given me more satisfaction and pleasure than anything I ever have done. Last year we distributed three-and-a-half million pounds of food to the needy through many churches in the city."

Our 60th reunion committee held a meeting in the M.I.T. Faculty Club on Friday evening, November 6, 1987, under the chairmanship of Jerry Gardner. Those present were: **Bill Baumrucker, Jr.,** Mr. and Mrs. **Karnig S. Dinjian,** Mr. and Mrs. **Paul F. Donahue,** Mr. and Mrs. **Jerry Gardner,** Professor and **Mrs. Herman (Fritz) Meissner,** Mr. and Mrs. **Joseph L. Speyer** and Mr. and Mrs. **David H. Wilson.** A majority of the members agreed that our reunion should be centered around or near the M.I.T. campus beginning Tuesday and ending Friday evening. Our own class activities will take Tuesday and Wednesday, and, as usual, we will join all the rest of the classes for Thursday and Friday's activities planned and directed by the Alumni Association Technology Day Committee. In the spring of 1988, you will receive a brief outline of what the committee is planning and will be asked for your input.

I regret to announce the deaths of the following members: **Romeo H. Guest** of West End, N.C., on August 4, 1987; and **I. Theodore Malmstrom** of Honolulu, Hawaii, on August 27, 1987.

I received a letter from Ted's wife, Florence, in September as follows: "Regretfully, I would like to tell you that Ted passed away on August 27, 1987. He died peacefully at home. His condition had gone from bad to worse for the past two years, from a cane to a walker to a wheelchair, which made it difficult to travel. He lived and enjoyed life with an optimistic view. Never did he complain about his condition for 23 years after that fateful accident in New York, after which he stayed in the hospital for nine weeks and a year of occupational therapy. His life lay in balance all that time. Most every morning he would say 'I am thankful that I have another day to enjoy that I did not expect.' " Having taken advanced R.O.T.C., along with his degree, Ted received a commission as second lieutenant in the Army Corp of Engineers. One of the first jobs he had was with Stone & Webster, working on the Bagnell Dam in Missouri. In 1933 he went to work for the Bureau of Reclamation in Denver, Colo., building earth dams. In 1938 joined the Army Corp of Engineers headquartered in Providence, doing various public repair work in Rhode Island and Springfield, Mass. In 1941 he went into the Army Ordinance, building a number of plants. He became the C.O. of a plant in Kansas. He went overseas with the Army Corp of Engineers just in time to celebrate V.E. Day. After the war, he started to work for the Coca Cola Export Corp. for six years in Johannesburg, South Africa, building their bottling plants. In 1949 he came back to the states on leave to attend the 20th reunion. In 1952 he joined Stone & Webster as an assistant chief engineer, working on the Gaston Dam in Roanoke Rapids, N.C. The last job he held before his accident was with U.S. Fish and Wildlife, where he was a regional director of the Northeast District. He designed a fish ladder on Cherry Creek, Vt., so that the salmon could climb up to their spawning grounds. It was Florence's love and care which made it possible for Ted to live and enjoy life for 23 years after that fateful accident.—**Karnig S. Dinjian,** Secretary, P.O. Box 83, Arlington, MA 02174

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From Ossipee, N.H., we have a report that last spring **Maurice (Yicka) Herbert** and his wife Maryan had a most delightful cruise from Vienna down the Danube to the Black Sea and on to Istanbul on a Russian boat with a Russian crew that, except for a few interpreters, spoke no English. M.I.T. alumni and their spouses comprised about a third of the passengers. The Herberts "found the Russian crew to be very friendly" but "the food was second rate." It appears that the Russians run 12 of these cruises down the Danube each season. Yicka is now fully retired. His oldest son Scott, is running the business for him, and Yicka says "although I hate to admit it, much better than I ever did."

In commenting on **George Wadsworth**'s death, he notes that he is now the last survivor of the two-mile relay team that ran in the IC4A track meet in New York in 1930. In addition to George, the deceased members of the team were **Dick Berry** and **John Jewitt.**

Tom MacLaren also comments on ancient athletic glories. Along with **Dave Wells** and **Harold Fairchild**, Tom was a member of M.I.T.'s 1929-30 gym team that won an NC4A championship. Tom has recently been watching and impressed by the Interamerican gymnastic competition in Indianapolis. Tom retired some years ago as general sales manager of Brown & Sharpe Mfg. Co. and now lives in No. Kingstown, R.I. . . . Last August 27 M.I.T.'s Undergraduate Education Office held a "Smith Day" reception to honor **Greg Smith** on his 80th birthday. As many of you know, Greg is a life member emeritus of the Corporation and since his retirement has devoted a great deal of time to the UROP program, as well as lesser amounts of time to the Community Service Fund and Council for the Arts. . . . **Jim Morton** writes from Sarasota, Fla., that he has now been retired from his investment counsel activities with Loomis Sayles in Boston for 15 years. He notes that "apparently this has triggered a major stock market advance, so something good has come from my retirement." He says he still enjoys investing for the benefit of Uncle Sam and his family.

As the members of the Class of '30 move into their 80s, they are necessarily forced to deal with an increasing number of physical disabilities. **Bill Waite** reports from Wilmington, Del., that in December '86 he came down with a bad case of shingles and the after-effects have been quite painful. For several months the V.A. Hospital prescribed a variety of different drugs and finally gave up on his case. At the time he wrote he was trying to get along without any medication. His final comment: "If anyone has found a method of 'licking' the after-effects of shingles, I sure would like to hear about it!" . . . **Morell (Hijo) Marean** has developed a multiplicity of physical problems. His doctor "has prescribed a regime to help control my five uncureables (cancer, diabetes, neuropothy, arthritis and dry eyes) that demands time every day, not just when convenient. They all go with the territory, but as long as I can control them with Tylenol, an easy diet and exercise I won't complain." His residual energy is largely devoted to such domestic chores as "planning, buying, cooking, eating and cleaning up three meals a day plus house-cleaning." One recent boon is the fact that his daughter Carol is now working in Boca Raton and lives only a few miles from him. Last spring Hijo drove over to the Gulf Coast and had lunch with the **Jack Bennetts** at their lovely home on Sanibel Island. Both were in good spirits and health, although Anne's activities are somewhat restricted by emphysema." Jack has "trained a wild hawk to answer a policeman's whistle and to take hunks of meat out of his hands. Quite a sight!"

This month we have a notice that another of our classmates, **Richard Hartwell**, died on June 15, 1987. According to my records, upon graduating from M.I.T. Dick worked briefly for Waltham Watch and then returned to M.I.T. on a research project sponsored by American Can. When this project ended he accepted a job from the sponsor that lasted until his retirement. His work for American Can was focussed largely on a long-term, in-depth study of the factors causing the corrosion of tinplate. He compares this research to peeling an onion. Each time he identified a corrosive factor and found a way of controlling it, another problem would appear. After his retirement he signed up with the I.E.S. Corps and he and his wife spent some time in the Philippines where he helped a tinplate producer in the Manila area. At the time of Dick's death the Hartwells were living in Oak Park, Ill. My records, which could be out-of-date, indicate that Dick is survived by his wife Kathryn, a son Robert and two grandsons.—**Gordon K. Lister**, Secretary, 294-B Heritage Village, Southbury, CT 06488

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The Alumni Association sent most of the following information. **Frank H. Simon,** whose address is 7/24 Lourds Square, London, England, said that his present job is director of several John Brown & Co. subsidiaries and senior manager of J.B. Parent Co.

The following is the part I don't like to print. **Theodore C. Morrill** of 17 Webster Ave., Amherst, passed away on Tuesday at his home. During World War II he was a naval officer, and executive of Liberty Mutual Insurance Co. He was also a member of the Amherst Council on Aging. . . . **Julian P. Hastings** passed away on September 28, 1987 in his home after a long illness. He owned and operated Hasting's Men's Store in downtown Framingham for 30 years. During World War II, he served with General George Patton. . . . **Meryl H. Perkins,** who was a good friend of mine during our college days, passed away on May 23, 1987. His home was 301 Majors St., Santa Cruz, Calif. 95060. His wife, Emily survives him. . . . **Claude Machen** passed away on October 2, 1987. Claude was a fraternity brother of mine and I was especially saddened at his death. He leaves his wife, Jean. His address is P.O. Box 315, Melvin Village, NH 03850. . . . **Harvey B. Alexander** died on June 14, 1987. His home is P.O. Box 326, Northport, Ala. 35476. . . . Last but far from least is **August J. Breitenstein,** who passed away on July 10, 1987 and whose home address was 625 Ridgefield Ave., Pittsburgh, PA 15216. Our sincere condolences to all. Next issue I hope to have more information on our mini-reunion on the Mississippi river.—**Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, FL 32757; **John Swanton**, Assistant Secretary, 27 George St., Newton, MA 02158

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William B. Pearce, our class treasurer reports that 38 classmates attended our 55th reunion (usually with spouses). However, 62 classmates paid their $10 dues. Bill and Midge plan to spend their winter in Homosassa, Fla. in their usual manner.

Ben Chadwick writes that he has developed a spur on his left heel, and it threatens to ground him. Ben and Marion are scheduled to go to the Virgin Islands to celebrate their 50th wedding anniversary. They are to be accompanied by 16 of their children (and spouses) and grandchildren. We hope all goes well, and congratulations from your classmates. (Latest news says they made it.)

Eleanor Nealand Wrigley writes how much she liked our reunion. She enjoyed the tribute to Ed ("Bunny") and will always cherish the plaque. . . . **Morris Etsten** reports that he is in good health. He and his wife have recently returned from an Alaskan trip. It was all they hoped it would be. . . . Georgene and **Joseph French** have recently taken a trip to Spain and Portugal . . . **Francis Gowen** keeps very busy with his various hobbies—carpentry, gardening, church activities, and working with young people. He will make his annual trip to Italy, which he enjoys very much. . . . **Thomas Hannafin,** a widower, is feeling good, takes trips, and keeps in close tough with his six grandchildren.

Guy Lentini almost came to our 55th reunion. Try to make the 60th, Guy. He has a new electric organ, which is his main hobby right now. . . . **Warren Little** has a touch of arthritis. He exercises, goes boating, and works (or plays) with computers. . . . **Robert Minot** has just celebrated his 80th birthday. He and Kay enjoy relaxing. They are going to Bermuda for a week. Bob still has some architectural projects which keeps him as busy as he wants to be.

Rebecca and **Arthur Marshall** are going to Israel in November for the 'teenth time. They practically have three grandchildren. Wow! . . . Pick up a pen and write me something. I don't want to miss an issue.—**Melvin Castleman,** Secretary, 163 Beach Bluff Ave., Swampscott, MA 01907

33 55th Reunion

Leon Hyzen, Course IV, took quite a trip from San Clemente to Chicago; Newport, Rhode Island; and New York (where Leon's auction of stamp and postal collection was auctioned at Christie's, thence through the Panama Canal; Charleston, South Carolina; Miami, Florida; and Costa Rica. . . . **Morris Cohen,** now Institute Professor Emeritus, Course III, has received the Albert Easton White Distinguished Teacher Award from ASM International. He has also been named as a 1987 laureate of the Inamori Foundation's annual Kyoto Prize to be given in Japan on Novem-

ber 9.

A note from **Dick Morse** reports that **Fred Murphy** has retired to Falmouth on the Cape and will be chairman of the 55th reunion, which, thanks to Dick's foresight, will occur at Chatham Bars where we had such a good time for our 50th. Class Treasurer is now **Burt Webster**. **Mal Mayer** attended kickoff dinner for the fund drive and the alumni conference and the only other member of the class he saw was **Ed Simpson** and wife Ida. Grandson Chris (Mayer) is now in Ph.D. program in economics at The Institute.

Pat Amenta, M.E. and wife Mary retired 11 years ago, have been touring Europe and enjoying Elderhosteling. **Bob Dobson** is retired from construction, a widower, and busy with golf, travel, and civic affairs. Recommends cruise ship through Erie Canal and St. Lawrence from Providence, Rhode Island.

Obituary note: **Herbert C. Endly,** E.E. died on May 4, 1987. Mrs. Endly may be reached at 170 Horizons E., Apt. 211, Boynton Beach, FL 33435.—**William B. Klee,** Secretary, Box 7725, Hilton Head Island, SC 29938

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The only class news I have received since **Robert Franklin** left for Europe is the following. In late October, **Earl Murphy**'s wife wrote to say that Earl had passed away. **Malcolm Stevens** adds, "Earl was one of a group of us who went directly to Panama right after graduation. He stayed a little longer than most of us. When he returned, he embarked on a successful career as an electrical engineer, which he retired from only recently."—**George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Apt. 711, Chevy Chase, MD 20815

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This is the first time I have used a word-processor in doing these notes—kindness of one of my two clients. I have just received a letter from Martha B. Mooney with the sad news that her husband **Vincent Mooney** died on May 26, 1987 of heart failure. He was a Course VIA man and in many of my classes. "Since the 50th reunion he often turned to the big class picture identifying many with whom he spent those happy M.I.T. years. Most of his years were with aircraft firms where he worked on those mysterious black boxes, and on the shuttle and sky-lab instrumentation. He said if he had to plan his life all over again, he'd go to M.I.T. and be an electrical engineer." Besides his wife of 45 years he leaves five sons and two daughters: a mathematician, a professor of philosophy, a copy editor, a psychiatric social worker, a photojournalist, a geophysicist, and a customs broker. . . . **Irving M. Harlow**, Course V died in July, 1987 in Newark, Del., as reported by his widow Marian Harlow. I extend our sympathy to the surviving families.

Since I shall be writing the next notes right after New Year's Day I should have plenty of material from year-end letters. A letter, postcard or phone call would be very much appreciated.—**Allan Q. Mowatt**, Secretary, P.O. Box 524, Waltham, MA 02254

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Our class is represented in the higher levels of the Institute's Campaign for the Future by **Lou Stahl** and **Henry Lippitt**. Lou is a vice-chairman of the Corporate Development Committee for the Boston area, which seems to include most of New England, and Hank is a member of the Los Angeles committee. I imagine that many more of us will be involved in this great effort, and I ask that you not hide your light under a bushel, but rather send or call word of your endeavor for inclusion in these Notes.

Phoebe and I attended the opening festivities in Cambridge October 23-24, at which the goal of $550 million was announced (with $210 million already pledged or in hand!). A multiple-image fade-in-fade-out slide presentation, prepared especially for alumni gatherings, was shown at the dinner and will be available for use around the country. I think you will enjoy the voices and images of our day—Karl Compton, Tubby Rogers, Doc Edgerton, Van Bush, Oscar Hedlund and others—and a brief but good picture of President **Alice Kimball** taken in the Great Court last year.

Alice was not present unfortunately, because the Notes for the August-September issue announcing her mini-reunion October 24 were set in concrete before the Institute's gathering was announced. At her West Hartland home were daughter Martha, **Pat Patterson,** Marian and daughter Marcia; **Fred Assmann** and Mary, **Larry Peterson** and Lillian, **Eli Grossman** and Vivien, **Augie Mackro** and Virginia, and **Ken Arnold** and Pauline. They made it a celebration party when it developed that the 24th was the Petersons' 46th wedding anniversary as well as Marian's birthday, and Alice's three days earlier. The Assmanns had been in England part of the summer. Late the previous winter Eli had dinner with **Spencer Mieras** and **Leo Kramer** and both were well.

The January Notes included **Bob Lutz'** account of a devil-may-care "paper cub" flight in 1934 from Boston to Washington and return. How many of us, at some point in our younger days, were in a similar situation when our guardian angels seemed to be watching over us? If such were part of student life, or involved classmates later, it could make interesting reading in future Notes. I'll tell one on myself: In the Spring of 1934 the Varsity, J.V. and 150's rowed against Columbia on the Harlem River. Two substitute heavyweights, port and starboard, and two lightweights, went along on such trips in case a regular had some indisposition, but on the morning of the race we were not needed. So we borrowed a Columbia "four" shell and took a spin to where the Harlem enters the Hudson, above the George Washington Bridge. The Hudson looked quite calm (as a mile of water is apt to do to eyes only three feet off the surface) and someone suggested that just for the hell of it we row to the New Jersey side. Great! But in midstream our cox **Harlan "Shorty" Hubbard** was barely able to keep us afloat by bailing furiously with his hat. On the Jersey side, standing in the tidal muck under the Palisades, we were tempted to somehow get to a telephone and call the boathouse for help, but that would reveal our indiscretion. So we heaved the shell overhead to empty it, and once again courted trouble and tempted fate across the Hudson. True, all oarsmen have to be good swimmers, but if we had had to abandon ship, the shell probably would not have survived the Hudson tide and numerous hazards—if it were found at all. Another of the four was a classmate, I believe, and I would like to hear from him and reminisce. Let's hear from all of you about your unforgetable moments.

We are at, or nearing, the stage of life when a last hurrah for our noble Institute is in order. We did well for our 50th Reunion Gift, and everyone is urged to open up one last time for the Campaign For The Future, which is for the future of the country as well. Personally, I could not have returned sophomore year without a scholarship loan, and at one time in 1934-5-6 three of the four class presidents and leaders of several major activities were working part-time to supplement such help. Today, about 600 of the entering class of 1991 need an average of about $12,000 in grants, loans and/or part time employment to survive. And they must be a good bunch of strugglers, because well over half of the young men and women of this class worked part-time while students in high school, in addition to summer jobs, to get started at M.I.T.—**Frank L. Phillips**, Secretary, 901 Los Lovatos, Santa Fe, NM 87501, (505) 988-2745; **James F. Patterson,** Assistant Secretary, 170 Broadway, Pleasantville, NY 10570

BRONZE BEAVER

The 1987 Bronze Beaver Award to Joseph F. Keithley, '37, whose " 'sky's the limit' approach to the most significant challenges is typified by his leadership of his class' reunion fund, resulting in an extraordinary 50th reunion gift. His deep caring for M.I.T. is as clearly evidenced by his commitment of time and energy to the Institute as by his generosity to it."

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Edward L. Bartholomew, Jr., of Marion, Mass., retired April 1971 as professor of metallurgy, University of Connecticut. In semi-retirement he continues as a grower/member of Ocean Spray. He recently published "Metallurgy of Cast Ferrous Alloys" and is also co-author of *Introductory Engineering Materials*. Non-work activities in spring and summer include sport fishing, lobstering, shell fishing, gardening, and boating/sailing. Fall activities include woodworking, cutting fire wood, and yard work. In winter he travels and swims. Ed writes, "We spend the first four months of the year in Tucson, Ariz. Our last extensive trip was to Maui in February 1987. Wife Sara's main interest is family and home and most of ELB's activities. Our plans for the future are quite simple, just more of the same since retiring."

Alfred E. Busch of Naples, Fla., (winter) and Short Hills, N.J., (summer) retired in 1982 as chairman of Keuffel & Esser Co., Morristown, N.J. He was on the board of directors of three insurance companies, two banks, one rubber company, and one valve company. He was also a member of the board of trustees of the local hospital and a member of the board of the local Y.M.C.A. In 1963 he was named Executive of the Year, State of New Jersey. His hobbies are (bad) golf and travel.

Douglas M. Carter of Rye, N.H., worked for Gillette Safety Razor in South Boston as a cost accountant from 1937-1942; Supship Quincy at Fore River Shipyard, Quincy, Mass., naval architect, 1942-1946; Fay Spofford & Thorndike, Boston, Mass., structural engineer, 1946-1947; and Portsmouth Naval Shipyard, Portsmouth, N.H., naval architect, 1947-1978. He married wife Erma in 1946. They have three sons, three grandsons, and three granddaughters.

Eugene P. Cooper of La Jolla, Calif., worked as a research physicist (The Franklin Institute), physics professor (University of Oregon), scientific director (Naval Radiological Defense Lab), consultant (Naval Undersea Center), and research management (Naval Ocean Systems Center). His accomplishments include development of a unique gun/rocket sight during World War II, helping initiate the navy's lightweight torpedo

CAMPAIGN

The Kick-off

Norman Leventhal, '38, as one of the speakers at the launch of the* Campaign for the future, *reported that the Boston area committee raised $46.6 million towards the Nucleus Fund. He said that the volunteer organization is already in place in Boston and that the local campaign leaders themselves made substantial contributions to the campaign goal. "Not a single person we asked when we were recruiting volunteers for this phase of the campaign said no," Leventhal said.

program, conducting measurements at nuclear weapons test sites, and supporting research which generated major navy systems programs. His hobbies are classical music, piano performance, stereo and tape collecting, walking, and swimming. He spent six weeks in the fall of 1982 in U.K., Sweden, France, and West Germany studying foreign laboratories. He is a member of the American Association for the Advancement of Science and a fellow of the American Physical Society. He has been married to Marjorie for 44 years. They have one son, three daughters, three grandsons, and four granddaughters.

Donald S. Duncan of Manchester Center, Vt., retired in July 1977 as professor of physics, Pratt Institute School of Engineering, Brooklyn, N.Y. His hobbies are photography and travel. He married Jean in 1946, and they have two sons. Travels have taken them to England, Scotland, France, Italy, Greece, and Israel. Dunc writes, "In 1985 my wife and I visited our three favorite cities, where we had been before—London, Paris, and Jerusalem." Wife Jean's main interest is writing.

Maxwell E. Jacobs of Brooklyn, N.Y., is self-employed as a manufacturer of weighing equipment, Brooklyn, N.Y., Cranford, N.J., and Los Angeles, Calif. He was adjunct lecturer of New York City College and served as chairman of SME Chapter 34 New York. His hobbies are tennis, computer hacking, and sailing. He has been married to Hazel for 44 years, they have a son and daughter and one grandson.

Sidney Mank of Washington, Va., retired March 1976 as president of Mank Construction Co. Sid is a board director and hearing Chairman of the Lions Club. He also works as needed in community volunteer duties. He writes, "Our son Andrew and wife Sally have moved out this way and are building a new home themselves. Great to have them nearby. Wife Dorothy's main interest is gardening and community work. Restricted lately due to care of parents on both sides. In addition, since February, 1987 have been in new home, landscaping and settling in. Was in hospital in January for a minor heart ailment which became full blown in July when I had a seizure. Now wear a pace maker. Hated to miss the reunion but this was also my year for the removal of a sarcoma in the arm. Am feeling great now and working just as hard as ever. Just to round things out, Dot had a knee operation early in June, another reason we bypassed the reunion."

Gilbert C. Mott of Fairfield, Mass., is retiring as vice-president for development and planning of Bridgeport Engineering Institute, a post he took upon his retirement in 1982 as vice-president for planning and energy of The Olin Corp., in Stamford. While his latest retirement officially takes effect August 31, he plans to continue his present activities with BEI as a volunteer. His long association with BEI began as an instructor in 1937; he remained on the faculty until 1942 when he entered the navy and served as a lieutenant from 1943 to 1946. He was honored by BEI in 1974 with an engineering doctoral degree and in 1976 was elected a trustee.

C. Ehrler Wagner of Woodland Hills, Calif., worked as a design engineer with Worthington Corp., Buffalo, N.Y.; Bell Aircraft, Niagara Falls, N.Y., and N. American Aviation (now Rockwell International) Los Angeles. He married Dorothy V. in 1948. They have two sons, three daughters, two grandsons, and four granddaughters. He is doing work on riding trails in the Santa Monica Mountains, has an Arabian horse and a mule, and rode rim to rim at the Grand Canyon in Arizona.

James Warburton of Alamo, Calif., worked as a refinery and chemical plant process design engineer for the M.W. Kellogg Co., and Chevron Research Co., New York and Richmond, Calif. He married Ruth Langletz in 1943, and they have one son. Hobby is dog breeding and showing.

Walter S. Wojtczak of Sarasota, Fla., (June to October) and Newbury, N.H. (November to May) retired February 1985 as senior vice-president, Standard Builders, Inc., Hartford, Conn. Wally and wife June R. have a son, a daughter, a grandson, and a granddaughter. Wally writes, "I'm now fully retired and concentrating on tennis, puttering around, and a host of community activities. Reunion was great. Anytime any of the class is in either of our areas, hope they will give us a call. Looking forward to the 55th, 60th, and 65th."

I regret to report the death of **William B. Bergen**, who died October 9, 1987, at his home in St. Michaels, Md., of cancer of the lung and esophagus. He was 72 years old. He retired as president of the space division of North American Aviation, Inc., the prime contractor of the Apollo space program, from 1967 to 1970. He left the company, whose name by then was Rockwell International, in 1978. He is survived by his wife Eleanor, a son, William Jr., and a daughter, Lynn Bergen.—**Lester M. Klashman**, 289 Elm St., No. 71, Medford, MA 02155

38 50th Reunion

1938 in 1988 is proceeding apace. Reservations are coming in daily for our 50th, June 1-5. While I can't speak for Boston, everything will be coming up roses at the Chatham Bars Inn.

Class Gift chairman **Ed Hadley** and his bride Jean took a respite from his fund-raising duties last fall, visiting Poland, Germany, and Norway, where they saw son Matthew, who also presented them with grandchild No. 11. Ed, now that you're rested, get back to work on the class gift.

Charlie Maak, living in Wichita, sent me a clipping of **Given Brewer**'s obituary. Charlie, please read the class notes more carefully.

I received word that **Rolland French** had a stroke and lost the use of his right arm. He gets around a bit with a cane.

Ted Burke passed away last June. He had retired to Volant, Pa. after having been vice-president in charge of sales for Whitney Kemmerer of New York City. Ted is survived by his wife Kathryn.—**Armand L. Bruneau, Jr.**, Secretary, 663 Riverview Dr., Chatham, MA 02633

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The **George Morrisons** expect to see the Super Bowl game in San Diego. To rest up from all the cheering they plan a month's cruise of the South Pacific including stopovers in New Zealand and Australia.

Jim Barton and Mary visited in New England and saw **Gordon Pope** and Trixie in New Hampshire. Gordon's recovery is on schedule and the Popes are active in New Hampshire and with travels to Florida and California.

Burk Kleinhofer writes: " . . . Just had a mini-reunion here in Long Beach. **Gail Swan** and Jeanne were our house guests from Dallas. **Sears Williams** and Jo timed their trip (to visit brother Craig Williams, '44, in nearby Huntington Beach) so we had a fine mini-reunion, especially enriched by comments stimulated by going over Gail's photo album. We all are looking forward to our 50th on the Cape. Also just heard from **Bert Pacini** and Tess from New Hartford, N.Y., who report they are enjoying the good life. . . . "**Bill Pulver** and Adie joined many '39ers in becoming busier after retirement than before. Bill and Adie sold their automobile dealership and made a whirlwind tour of New England where they saw **Joe Dana** and Jean at Chatham and **Dodie Casselman** at Cataumet. Returning home to Lakeville, Conn., Bill and Adie found a different kind of whirlwind and snowstorm had come and gone, leaving a huge assortment of broken branches and rubble the disposal of which helped Bill discover muscles he hadn't been using on the golf course. The pleasure of a surprise visit from **Bob Schmucker** and Jeanne added fun for all at another Pulver mini-reunion.

Art Zeldin travelled for five weeks in Indonesia, Singapore, Hongkong, and Japan before returning to Salt Lake City and retirement activities including golf.

Burt Rudnick continues active in real estate in the greater Boston area and just started a new enterprise for international trading.

We are saddened by news of the death, on September 6 in Scottsdale, Ariz. of **Gordon E. Holbrook**, Course II. There were no details.

For our 50th reunion **Jim Barton** will chair the Class Gift Committee. **Harold Muckley**, life member of the M.I.T. Corporation, has consented to be honorary chairman. Jim was overwhelmed by enthusiastic responses from 29 classmates who volunteered their help.

Traditional highlight of Class Day Luncheon each June is formal presentation to M.I.T. of the gift from the 50th Reunion Class. In June 1989 our Class Gift will include all gifts from '39ers during the prior five years. Giving by '39ers toward our 50th Anniversary Class Gift already exceeds $900,000.

First meeting of the volunteers is to be February 9, 1988 at Holiday Inn Embarcadero in San Diego. The vanguard of volunteers includes 30: **Harold Muckley**, Honorary Chairman; **Jim Barton**, Chairman; **Pete Bernays, Bill Brewster, Phil Bush, Dodie Casselman, Hal Chestnut, King Cummings, George Cremer, Dick Donohoe, Fred Grant, Mike Herasimchuk, John Herlihy, Harold Hindman, Burk Kleinhofer, Jim Laubach, Dick Leghorn, Leonard Mautner, Charles Mercer, Manning Morrill, George Morrison, Bill Murphy, Morrie Nicholson, Larry Perkins, Irv Peskoe, Fred Schaller, Hal Seykota, Paul Stanton, Oz Stewart, Ted Wroblewski.**

After scanning this roster of shakers and movers your secretary suggests Classmates Muckley and Barton will be presiding over generation of great fun and the unique personal satisfactions that come to individuals who extend themselves to accomplish improvements in the welfare of others. Classmates desiring to give or receive information and other values may phone Jim Barton (206) 462-1316, or any others named above. Incidentally, classmates enjoy news about those with whom they shared four or more years; feel free to use these notes and your secretary will try to

spell all names correctly.—**Hal Seykota**, Secretary, 1701 Weatherswood Dr., NW, Gig Harbor, WA 98335

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Class members have been traveling far and wide. A recent telephone call to Class President **Jim Baird**'s office elicited the information that he is in China for the next few weeks. I look forward to comparing notes with him when he returns. I have also received word that **George E.B. Hill**, of Kentfield, Calif., is on an extended trip to Finland and Russia. Perhaps he will share some of his experiences with us for a future issue of the *Review*.

Albert L. Carpentier of Lawrence, Mass., sent a note that he retired from Polaroid after 30 years of service as manager of facilities engineering.

Class Treasurer **Edgar L. Bernard** sent me some statistics regarding our class. He notes that we have 459 living members. In September 1987, he sent invoices to 402 of those. (A number of members were already paid up for 1987-88, and a few others requested that they not be invoiced.) To date, 181 people have paid their dues. Of these, 30 were paid up through 1990, and four were paid through 1989. By the time you read this, I hope many more of you will have sent your dues to Ed.

Ed Bernard also reports that he is making advance payments to the hotel in Mystic, Conn., as a deposit for our reunion there in 1990. Plans are proceeding for our gala 50th. If you have any thoughts in regard to the reunion, please send them to any of the officers or to me.—**Richard E. Gladstone**, Secretary, 1208 Greendale Ave., Needham, MA 02192, (617) 449-2421

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John Holmes MacLeod, who many classmates remember as a swimmer, a coxswain, and an ardent sailor, writes that DeeDee, John, and their children and grandchildren sailed from Narragansett Bay to Nantucket and back last August. Once a sailor, always a sailor. From there, he rushed off to catch his 50th high school reunion at Sandusky, Ohio.

Calvin Dodd MacCracken, a transfer student from Princeton, is the owner of the Calmac Manufacturing Corp. in Englewood, N.J. Calvin, an inventor for almost four decades, primarily in heating and cooling technology, talked at the Fairfield Public Library about the invention and commercialization process and about his experiences as an inventor. Among his many inventions is the temperature distribution system that was used in the Appollo astronauts space suits.

In the course of his career, he has worked with Theodore Edison, son of Thomas Edison, and, during World War II, was at General Electric helping develop the then top secret jet engine. He holds 80 U.S. patents and 250 foreign ones and has received grants from the Department of Energy and from NASA, as well as from other government agencies. Calvin is the author of *A Handbook for Inventors*.—**Joseph E. Dietzgen**, Secretary, P.O. Box 790, Cotuit, MA 02635

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I had a great two weeks in September with **Jim Hoey** and Jane at their home in Cape Cod. We caught a mess of big bluefish and spent hours cruising Pleasant Bay, and I finished wiring his new sunroom. He's very active in the Chatham Coast Guard Auxiliary. We called **Frank Swenson**, in Wisconsin, who has retired from his radiology doctoring. Both Frank and Polly had major surgery bouts last summer; are better now; and will join us in Newport for the 45th. Jim received a call from **Tony delValle** and Carmen, who had recently visited **Fred Kaneb** in Montreal, Canada. "Bull Moose's four children are active in his oil distribution business, and he and Mayford plan to be at the reunion in June.

Betty and I enjoyed a beautiful evening in late October with **Bruce Horst** and Pat, who were here in Palm Springs at a convention. He has two companies: one is the largest supplier of medical screws and the other makes machine tools for deburring. Pat just started a new business, "P.J. Maxwell," for the nationwide sales and distribution of cosmetics under their own brand names. The Horsts divide their time between their riverfront estate in Rockford, Ill., the winter place in Naples, Fla., and a "cottage" on Lake Geneva, Wisc. Bruce used to play a few rounds of golf semi-annually with **George Marakas**, at machine tool conventions, until George retired two years ago as president of Kearney-Tracker in Milwaukee and moved to Florida. Bruce has visited with **Greg Gagarin** in the Washington, D.C., area quite often. Greg utilizes his multi-lingual proficiency in his travels as president of Knorr Brake Co., a world-wide German-based firm.

Gene Eisenberg, CEO of LEA Group, Engineers, of Boston, called me last week to renew his subscription to my quarterly newsletter, "Construction Contracts." His firm moved up to No. 285 of *Engineering New Record*'s top 500 design firms, now exceeding $10 million annually in billings. Reunion chairman **Mort Spears** telephoned me in mid-September, informing me that "publicity" will be generated in Cambridge, instead of from the 19th hole at my golf course here in the desert, and that **Ralph Leader** will take on some added responsibilities. So I called Ralph, who assured me of great plans for conviviality at the Viking Hotel in downtown Newport, R.I., a great dinner dance at the Vanderbilt estate, etc. I trust you all have paid the $25 class dues (I think we already had a kitty of over $3,000) and received the November envelope full of sightseeing brochures.

I expect a golfing visit early in December from **Iz Lenzner**, who recently retired from management at Industrial Chemical, Mt. Vernon, N.Y. His wife, Doris, died in an auto accident in the Spring of 1987. He is adjusting pretty well and is thinking of moving to Aspen for skiing or Southern California for golf, or both. I had already started writing these notes when I received the following letter from another of my newsletter subscribers, **Tony delValle**, whose businesses in Puerto Rico encompass construction, banking and rum. I pass it on in toto, because I can't translate his Spanglish. "Guess who blew out of the sky, "**Gus Calleja**, with his sister and youngest daughter. He told me he has been living in Venezuela for the last decades. Undoubtedly he will be at the reunion, which unfortunately I will miss. He is still a youngster at heart; we had quite an evening for his mind is quite alert and has an exceptional memory.

"I am still fishing and enjoying the sea including the beaches and the things that populate them in this beautiful Island. In the last month we had the International Billfish Tournament in which 131 blues were caught, a world record. Unfortunately, my 60-foot Hatteras Convertible only caught two. That was better than average, for there were 96 boats fishing. Con un abrazo."—**Dick Feingold**, Assistant Secretary, 260 N. Hermosa Dr., Palm Springs, CA 92262, (619) 323-4447

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Heard from three of our classmates this month. **Egilda (D'Amicis) Witherell** retired in September 1986 from her post as radiological physicist at Newton Wellesley Hospital. At present she is recovering nicely from a heart attack suffered in April 1987. We wish her a speedy recovery. . . . **Robert V. Bruce**, professor of history in the Boston University History Department published *The Launching of Modern American Science, 1846-1876* in April 1987. . . . **Bob Breck** writes that he and Priscilla are down to caring for two houses and that he keeps busy in retirement but misses the big projects and the daily contact with lots of people. Bob had a distinguished career in the insurance industry and at the time of his retirement was vice-president of American Mutual Liability Insurance Co.

John Gardner and **Andy Corry** were on a program celebrating the 40th birthday of the Insulated Conductors Committee of the IEEE. Each had been chairman and tried to give the benefit of his experience to those now charged with its mission to be the lead committee of the IEEE in matters in which the dominant factors are the design, construction and operation of insulated conductors used in all aspects of electric power. Keep your eyes peeled for news of the 45th. June 1989 is not too far away.—Co-Secretaries: **Andy Corry**, Box 310, West Hyannisport, MA 02672; **Lou Demarkles**, 53 Maugus Hill Rd., Wellesley, MA

CAMPAIGN
The Kick-off

Carl M. Mueller, '41, chairman of the Corporation Campaign Committee, spoke at the kick-off for the five-year capital campaign. Mueller said that the need for volunteer leadership in the campaign is a simple matter of arithmetic. There are 70,000 alumni to be contacted, and no way that the faculty, administration, and staff of the Institute could do it in five years without massive support from alumni volunteers.

Mueller commented on the number of members of the class of '41 who have substantial roles in the campaign. He noted that people who graduated in 1941 are at or near retirement age and may have more time for such activities. But he hinted broadly that there were surely other qualities at work in the leadership of classmates Joe Gavin, immediate past president of the Alumni Association, and Reid Weedon, chairman of the National Campaign Committee, among others.

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Sitting here on Denver's LAST DAY of Indian Summer (tomorrow the deluge), watching Andy Bean wrap up the Kapalua International with a record 21 under, reminds me of **Bill Cahill**'s experience there several years ago playing with Lee Trevino. How's the golf game, Bill? Other than this bit of trivia, there isn't an iota of news to pass along. So I'll just delve into the bio book for whatever excitement we can muster.

And right away I run into yet another overlooked SVIer. **Sheung Chin**, a Providence (R.I.) lad, who must have been in some of my classes

BRONZE BEAVER

The 1987 Bronze Beaver Award to Emily V. Wade, '45, "who has served M.I.T. and the Alumni Association at every level of involvement from Alumni Association national committees and Board of Directors through membership on Corporation Visiting Committees, the Corporation itself and its Executive Committee. She has given an enormous amount of her many volunteer commitments to M.I.T., where she invariably serves with distinction and grace, wisdom, and wit."

(probably those I slept through). Anyhow, he went straight into Martin and stayed (survived) for 27 years before retiring in 1973, but not before becoming chief of aerodynamics and writing a book, *Missile Configuration Design*, which McGraw Hill published in 1962. Sheung ended up in Maitland (near Orlando), Fla., where he lives with wife Ruth and is involved in realty investment and development. The Chins have a daughter and two sons, one of whom is yet another Martin aerospace engineer.

Next there's **Bob de Fasselle**, out of Course XIII in the September segment, who went into the thermodynamics world, ending with his own company(s) in Cleveland, where he still lives in exurban Gates Mills with his "patient lady" of 41 years on a five-acre woodland tract. They have a son who's his vice president and best hunting/fishing buddy. Alons enfants, Bob!

Here's one I can hardly believe: **Ted (Thaddeus) Hawkes**, of Long Island origin and XVI/V-12 coursemate went into Sperry right off and on to Columbia University for his M.S. Then, in 1963, he emigrated to Paris where he spent 14 years with Thomason-CSF, getting his Ph.D. along the way. Finally back in the states, he went with RCA in Princeton as staff engineer and is living in Haddonfield (N.J.), my own origin!! Small world, Ted. Two daughters still live in Paris and another teaches French at Boston University, plus one teenage son. He hopes to retire in 1996 (in time for our 50th? C'mon, Ted! Get real), so he can fix up his Victorian period house.

Edward "Ned" Bowman, our distinguished academician, started out with his XV B.S. in the '47 June class, followed with an M.B.A. at Wharton School/University of Pennsylvania and a Ph.D. at Ohio State. Before/during/after all this, Ned spent 22 years on the Sloan School faculty, served as comptroller at Yale, dean of College of Administrative Science at OSU, and, currently, is professor of corporate management at Wharton. He lives, writes, "enjoys" in Gladwyn with wife Ann, while son John is a plant pathologist and daughter Susan is an artist.

Have I ever mentioned **Bob Bolger**? If not, I humbly apologize. Bob's another XVI/V-12 confrere, emanating from Brighton (Mass.), who picked up an M.B.A. from Hahved, survived 12 years with GE and another 15 with RCA in Indianapolis. He opened his own consulting office in Los Angeles in 1981. Along the way he fathered four children and has seven grandchildren all living in Indiana. Bob digs deep sea fishing, swimming, golf, and spectator sports. My kinda guy!!

And how 'bout **Ed Bean**, a handsome, familiar face in the *Technique*, product of western New York State and Course VI/V-12 refugee, escaped into law at Georgetown University while working in the U.S. Patent Office. Got his degree (LL.D.?) in 1950 and returned to his roots in/near Buffalo to begin his practice of patent law. Married Susan and sired three successful children. He now runs (and enjoys) his own show called "Intellectual Property Law." He plays "enthusiastic" tennis (don't we all) and sails "whenever possible."

I miss you all!!—**Jim Ray**, Secretary, 2520 S. Ivanhoe Pl., Denver, CO 80222

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Judy and **Graham Sterling** sent a note about the birth of Arlie Graham Sterling, IV, their first grandchild. The baby was baptized on their 35th wedding anniversary. . . . **Harry Jones** continues his merger and acquisition business involving small companies and/or divisions of large corporations. Harry is a catalyst for the changes of ownership of technology based companies. He also serves as midwife during the formation of the new entity. Harry and Ann, his wife, have a son Craig, who works for Drexel, Burnham buying and selling high yield bonds. . . . **Bill Bangser** operates his manufacturing business in Westport, Conn. Maiman Textiles provides machinery to cut cloth used by apparel manufacturers.

Curtis Green is still operating his oil well drilling business from Tulsa. Business is lousy, so he spends half his time playing golf. He and his wife Joan are waiting for the birth of their first grandchild. Curtis suggested that the class officers plan a presentation for our 40th reunion gift to M.I.T. He has pleasant memories of watching Cecil Green's class make their presentation at our 25th reunion. . . . **Howard Jacobsen** continues doing business with companies in the Orient. He visits the Orient at least once a year. In Singapore he stayed at the Shangri La, which is a pretty hotel with numerous luxurious features such as a bedside console to control the lights, draperies, and shades. When you open the door and enter, the room lights go on automatically. Although he is not currently active, in the early seventies, Howard was president of the local M.I.T. Club and solicited for the Alumni Fund.

Our class was well represented at this year's National Alumni Conference (NAC) in Cambridge. One faculty member who spoke at the NAC was Professor Alexander H. Slocum. Professor Slocum is the current holder of an endowed professorship, one of the highest honors a university can bestow on its faculty. Professor Slocum holds a chair funded in 1987 by our classmate **George Macomber.** George is president of the George B.H. Macomber Co. of Boston. George established a full professorship in construction management to carry out research and teaching related to the construction industry. Professor Slocum is currently designing and building robots to automate various construction tasks. The robots do specific tasks like build an interior wall. He is building a machine to measure centimeter-size surfaces with Angstrom accuracy. He has formed the Center for Systems Automation to train students to design precision computer-controlled systems. During his talk, Professor Slocum identified George's role in bringing Professor Slocum to M.I.T. from the National Bureau of Standards. It was easy to hear in Professor Slocum's presentation the characteristics that enable some faculty to be great teachers as well as researchers. M.I.T. will benefit in several ways from George's contribution of an endowed chair.

Some of our classmates who attended the NAC were: **George Macomber, Gene Ashley,** Imogene and **Jack Page,** Ann and **Harry Jones,** Gloria and **Sonny Monosson,** Jean and **Milton Slade,** Gwen and **Lou Kreek, Bill Bangser, Denny McNear,** and yours truly.

At a reception and dinner dance in du Pont Gymnasium, the atmosphere was completely changed by innovative draperies and backlighted windows in the draperies. A romantic touch of glamour was added by the having the backlighting behind the windows change several times during the evening ending with a subdued nightlight during the dancing. About 11:30 p.m. many guests had departed from the party, when **Sonny Monosson** observed that the Class of '48s table was still full and our class party was intact and going strong. On Saturday at the awards luncheon, **Gene Ashley** was presented with the Morgan Award. Details on Gene's award will be in next month's column. Paddy Wade, '45, received a Bronze Beaver award. **Jack Page** was one of our many classmates who was a freshman with Paddy in 1942.

Vince Vappi has been a member of M.I.T.'s Advisory Committee for Shareholder Relations for the past ten years. The committee has faculty, alumni, administration, and student members. One faculty member is Professor Robert Solow, a recent recipient of the Nobel prize in Economics. Recent discussions have emphasized M.I.T. ownership of stock of companies that do business in South Africa. Vince described discussions in earlier years of Nestle's sales of milk that substituted for breast feeding in undeveloped parts of the world. Vince is still chairman and CEO of his company, Vappi Construction Co., in Cambridge. He serves on several boards that take his time and interest. These include: John Hancock Mutual Life Insurance Co., The Boston Co./Boston Safe Deposit Co., Tech-Ops (a company with technical interest to Vince), Simmons College, Mass. Health and Education Facilities Authority, and New England Deaconess Hospital. After 35 years in his Milton home, Vince moved to Cambridge. He and his wife Judith have a condo at Charles Square. Vince still enjoys playing squash regularly, a little golf, and sailing his 35-foot sloop.

Jack Page continues to tailor his consulting activites to the current needs of organizations. He has been working extensively with health care groups helping them adapt to a competitive environment after years of charging patients on the basis of cost plus profit for the provider. Jack and Imogene have been busy taking care of grandchildren and have not made any adventurous sequels to their trips to Egypt and China. After the NAC, they took the grandchildren on a whale watching trip. Jack saw **Otto Wetzel** recently. Otto had just returned from scuba diving near Trobian Island in New Guinea. . . . **Don Atwood** continues as vice-chairman of General Motors. He is also a member of the M.I.T. Corporation and recently became a director of the NBD Bancorp of Detroit. . . . **Bob Rowe** and his wife have been living in Charleston Heights, S.C. for several years. He started a construction consulting business, and his wife became a college freshman. They are both busier (with no children at home) then they have ever been in their lives.

Bob Ginivan died following a long illness. He retired in 1981 from Monsanto and affiliated companies after 28 years of service. He had numerous positions in personnel and was director of personnel of Fisher Controls, a subsidiary, when he retired. . . . **Charlie Butter** died while on a cruise to Alaska with his wife Peg. Charlie had been an educational counselor for M.I.T. in Salt Lake City. He worked for Sperry Univac for 39 years. During our student days, Charlie was active in Delta Upsilon fraternity. . . . **Lloyd Hartman** died several years ago. He was with Lake Central Airlines at the time. Our sympathy to the families of our

classmates.—**Marty Billett,** Secretary, 16 Greenwood Ave., Barrington, RI 02806

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MITRE Corp. announced that **Alan J. Roberts,** currently senior vice-president and general manager of their Washington C3I Division will join the corporate staff in order to undertake special projects in Bedford and Washington.

Your secretary, **Marty Greenfield,** has some happy news to report. Our daughter Carole has become engaged to Dr. Richard Fellman. Carole, who is a product manager with Digital Equipment Corp., will be married in August. Our oldest daughter Leslie is married and working for Apollo Corp., while our youngest daughter Judy recently graduated from Bentley College. Our family has been biased toward computer careers. I am with Honeywell Bull, and my wife is in the MIS department of the Hit or Miss Corp.

Another proud father, **Frederick A. Radcliffe,** has a stepdaughter who is a freshman in the M.I.T. class of '91 and a stepson at U.R.I. Fred's son, Fred, Jr., is a civil engineer and PE. Fred's older daughter is in Texas, while his youngest daughter just turned three.

We just learned that **Roy W. Niemela** passed away in March 1986. We want to express our condolences to his wife Corinne and his children, Van, Doug, and Suzanne.

Relating other sad news, **Richard W. Willard** passed away in October. Willard was a former editor of the *Harvard Educational Review* and was primarily involved as an educational consultant. He served for a period on the selection committee for the National Merit Scholarship Corp. We express our sympathies to his wife Gail, his sons, James and Robert, and daughters, Allisan Healey and Larraine Menard.—**Martin N. Greenfield,** Secretary, 25 Darrell Dr., Randolph, MA 02368

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The New England Association of Chemistry Teachers (NEACT) last summer presented its 1987 John A. Timm award to **Dana W. Mayo** of Bowdoin College and to an associate at Merrimack College for their work in developing the microscale organic chemistry curriculum in 1980-81. Microscale reduces the consumption of materials and the threat of fire and explosion, permitting access to a greater range of experiments. NEACT credits Mayo with increasing the number of chemistry majors at Bowdoin from six to the high 30s over the past 25 years. Chemists pay five dollars a liter for water—very pure water, to be sure—and I can appreciate why reducing chemical consumption is a very attractive idea. It is an impressive achievement to combine efficiency and economy with more effective teaching.

Edwin Porter writes that he is still head of the Air Force and Defensive Systems Programs at C.S. Draper Laboratory. . . . Well, I am all for stability and, even if it is not news, it is good to hear.—**Richard F. Lacey,** Secretary, 2340 Cowper St., Palo Alto, CA 94301

53 35th Reunion

Plans for our 35th reunion in early June are moving into high gear, and a lot of interest is being generated. Make sure you reserve the date now and send in your deposit. It looks to me as if this will be our best reunion ever.

Several of our classmates have written notes about themselves and their families. **Dave Freeman** writes that his son Erik just started at Caltech, "where he hopes to improve his juggling." If I remember correctly, it was hard enough juggling classes, homework, labs, and dating in our freshman year, let alone anything else. . . . **Carl Wolf,** M.D. is continuing as director of the blood bank and transfusion service at the New York hospital, where he is also the attending pathologist. In 1987, he became professor of clinical pathology at the Cornell University Medical College in New York City.

A brief article in Draper Laboratory's *D-notes* informs us that **Ed Kingsbury** recently presented a paper in London at the International Tribiology Conference. Tribiology covers the interaction of sliding surfaces in three areas: friction, wear, and lubrication.

Finally, **Joe Mullen** writes from Honolulu that he and his wife Rita expect to be in Boston for the reunion. He hasn't missed a class of 1953 reunion yet, and he doesn't plan to start now. Joe is president of his own company, which specializes in thermal studies and steam generation. Besides working once in a while, he's enjoying himself swimming and playing golf. He's also enjoying good health and watching the bathing beauties. Joe's three daughters' homes are spread from California to Connecticut, and he has seven, count them, seven grandchildren. At the reunion we'll have to have a "greatest number of grandchildren" contest. Joe writes that he's been traveling all over the world, most recently to Cuba, where he gave a talk on energy and how to use indigenous fuels and efficient cycles.—**W. Haberman,** Secretary, 41 Crestwood Dr., Framingham, MA 01701

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Richard G. Schwind received the Melville Medal of the American Society of Mechanical Engineers at its winter annual meeting last December in Boston. The medal is awarded for the best original paper on a mechanical engineering subject presented for publication the preceding year. The title of the paper is "Experimental Variable Properties Natural Convention from a Large, Vertical, Flat Surface." In addition to the undergraduate degree, Dr. Schwind also received his S.M. and Sc.D. degrees from M.I.T. in 1956 and 1962. He began his career at TRW in Cleveland in 1956. From 1962 until 1969, he was at the Lockheed Palo Alto Laboratories. He then moved to Nielsen Engineering and Research, Inc., Mountain View, Calif., designing and supervising construction of its convertible water/wind tunnel with a 14-by-4-foot wind tunnel for mixed convection studies. At the Westinghouse Marine Division in Sunnyvale, where he has been since 1983, he has directed hydroballistics and blow-down facility investigations. He now supervises the measurement systems group, as well as various special investigations.

Please keep the information flowing our way.—Co-secretaries: **Robert P. Greene,** 37 Great Rock Rd., Sherborn, MA 01770; **DuWayne J. Peterson, Jr.,** 201 E. 79th St., New York, NY 10021

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Murray Gerber has been named to the University of New Haven Board of Governors. He earned an M.B.A. from University of New Hampshire in 1979. In the sixties, he founded Prototype & Plastic Mold Co. specializing in limited-life injection molds and short-run injection molding of plastic parts. Murray has been active in the business community for the past two decades. He was a Connecticut delegate to the White House Conference on Small Business in 1980 and chairman of the Second White House Conference in 1986, chairman of the Connecticut Business and Industry Association Ad Hoc Committee on Estate Tax Reform, and chairman of the 1982 Connecticut Conference on Small Business.

Currently, he is chairman of the Connecticut Public Expenditure Council; a director of the Connecticut Tooling and Machine Association, the Smaller Business Association of New England, and the Middlesex Chamber of Commerce; and is on the Executive Committee of the Connecticut Business and Industry Association. Murray and his wife Shirley took part in the class festivities at Newport on our 30th.

BRONZE BEAVER

The 1987 Bronze Beaver Award to W. Gerald Austen, '51, for "his significant gifts of time, energy, service, and wisdom to the M.I.T. community. As a member of several Corporation Visiting Committees and Alumni Association national committees, and as a life member of the Corporation and a member of its Executive Committee, he has served quietly, willingly, and effectively."

Edmund W. Pease was appointed deputy director of administration and planning for the Montclair (N.J.) Art Museum. Prior to this, he was an administrative officer at the Memorial Art Gallery of the University of Rochester (N.Y.) Edmund attended with us prior to receiving a B.A. in economics from Columbia and doing graduate work at Columbia, New York University Graduate School of Business Administration, and the Museum Management Institute in Berkeley, Calif.—Co-secretaries: **George H. Brattin,** 39 Bartlet St., Andover, MA 01810, (617) 470-2730; **Irwin C. Gross,** Sweets McGraw-Hill, 1221 Ave. of the Americas, New York, NY 10020, (212) 512-3181

58 30th Reunion

Back to the Vineyard: By popular demand, the class of '58 will return to the Harbor View on Martha's Vineyard for the 30th reunion. Plan to enjoy another super reunion weekend including the ferryboat ride to the Vineyard; poolside cocktail party and clambake Friday night; tennis, golf, beachcombing or sightseeing around Edgartown and historic Chappaquiddick Island on Saturday followed by an elegant dinner Saturday evening at the Harbor View. Dance the night away to the strains of that good music of the fifties.

Your reunion class chairman, **Roy Scarpato,** and the committee are hard at work putting it all together for your enjoyment. Reserve the weekend of June 3-5, 1988, for recreation and renewal of old friendships.

From Germany, **Bob Baber** writes that his second book, *The Spine of Software: Designing Provably Correct Software, Theory and Practice,* was published by John Wiley & Sons. According to Bob, it is another effort aimed at supporting the metamorphosis of software development to a proper engineering field. . . . Here in the States, **Hans Morgenstern** has formed a consulting engineering business, HGM Associates, in Edgewood, Md. . . . We are sorry to learn belatedly of the death of **Karl Thomas Ludwig.** He was a lieutenant colonel in the U.S. Air Force and had been living in Cupertino, Calif.

BRONZE BEAVER

The 1987 Bronze Beaver Award to John S. Reed, '61, "for his support of M.I.T. in a variety of leadership roles—director of the M.I.T. Club of New York, member of Corporation Visiting Committees and of the M.I.T. Corporation, and solicitor for the Alumni Fund."

BRONZE BEAVER

The 1987 Bronze Beaver Award to Susan L. Kannenberg, '61, for her "significant and positive impact on M.I.T. people and programs, particularly in the area of women's activities. Her deep commitment to M.I.T. and her tireless efforts on behalf of the Institute and its students and alumni stand as an example to other graduates."

Talked recently with **Dan Holland,** who said he is now competing in triathalons. According to Dan, he is in the top 4 percent of the people competing—in terms of highest age group! Despite this bold display of athletic prowess, Dan has begged off the task of organizing the athletic activities at the 30th reunion, even though he and Pat plan to attend. . . . Another son returns to M.I.T.: **Glenn Strehle**'s son, Andy, who is a freshman this year. According to Glenn, Andy decided to assert his independence, however, by pledging Phi Sigma Kappa instead of Phi Mu Delta. Glenn is now heavily involved in the major M.I.T. fund drive recently announced.

Watch your mailbox for more details about the reunion.—**Michael E. Brose,** Secretary, 841 Magdeline Dr., Madison, WI 53704

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The first snowfall of the season—an early nor'easter which dumped ten inches—has stranded me at home, so I shall take the opportunity to write this month's Class Notes.

A recently received news release announced the election of **Dick Collins** as president of the Arizona Medical Association. Dick is an orthopedic surgeon and has been in private practice in Scottsdale, Ariz., since 1971. Dick graduated with us from Boston Latin and attended the Institute for several years before transferring and graduating from the University of Notre Dame. . . . Another press release notifies us that the firm of Voinovich Monacelli Architects has been chosen as part of the team to design and build a new Suffolk County Jail to replace the old existing Charles Street Jail. **Bob Broder**, a director at Voinovich Monacelli, is quoted in the release as supporting the Sheriff's intense concern for not compromising the security issues in the correctional planning of this high visibility project. The $50 million facility is scheduled to become operational in March 1990.

A newsy note from Seattle written by fellow-course Iller **Bud Haselton** informs us that, "At present, I'm living serenely on a houseboat (so I'm still happy), my liver is functioning well (so I'm still healthy), my two grown children are both in college (so I'm still poor) and I'm developing a sure-fire system to beat the horses (so I'm still dumb!). Life is a platter of delights."

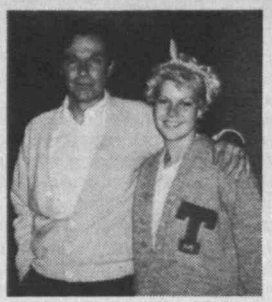
A release from IBM announces the appointment of **Juri Matisoo** as research division vice-president of storage and director of the Almaden Research Center in San Jose, Calif. Prior to this appointment, Juri was director of silicon technology at the Thomas J. Watson Research Center in Yorktown Heights, N.Y. He joined IBM in 1964 as a research staff member and is a fellow of the IEEE. In 1978 he received the Jack A. Morton Award for outstanding contributions in the field of solid-state devices.

Professor **Daniel Wang** has been appointed to the Chevron Professorship at the Institute. Dan, who is also director of the Biotechnology Process Engineering Center, joined the faculty in 1965, became an associate professor in 1970 and professor in 1974. He and his wife, Victoria Dawn, an assistant vice-president of the Bank of New England, have one son Keith who is 14 years old.

On a final sad note, we received a beautifully touching letter from Mrs. Beatrice Szekely notifying us of the recent death of her brother, **Phil Beach**. " . . . Phil was president of Delta Kappa Epsilon and editor of *The Tech* in his senior year, as well as a member of the sailing team. He received his S.M. from the Sloan School and then was associated with the Harvard-M.I.T. Joint Center for Urban Development, first in Freetown, Sierra Leone, and then in Caracas, Venezuela. He remained in Latin America for the remainder of his career, most recently in Salvador, Bahia State, Brazil.

Phil was enormously proud of his M.I.T. training. Professor Carol Wilson was very influential in his career choice of international development. Unlike many of our generation who went abroad after college for a few years of study/work, Phil remained overseas. He was involved in the food industry in Latin America for over thirty-years. . . . The brain cancer that he died from was a year-long illness. His daughter Alicia is entering Wellesley this fall. Perhaps she will cross-register for courses at the Institute as she has the potential career interest in engineering. Phil expressed that hope in the final months of his struggle." Our heartfelt sympathy goes out to Phil's family.

Until we talk to you in the next edition of Class Notes, please take care.—**Arthur Collias**, Co-secretary, 24 Hemlock Dr., Canton, MA 02021; (617) 828-5073



"In my 25 years of faithful reading of* Technology Review, *I have but one complaint—your coverage of fashion news has been scant," writes William J. "Sandy" Wagner, '61. To help remedy this, he sends a photo showing what California girls are wearing today. His daughter Alice, 17, models the letter. "I am sure that many readers will take heart at this sign of historical (not to say, archeological) interest among the young," he says.

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Pat Coady passed on a letter he recently received from **David Marshall**. David lives in North Reading, Mass., with wife Bette and their three children. David reports that he and Course X classmate **Earl Pike** founded and recently sold a company specializing in a copper containing conductive resin that David developed. He is now consulting in adhesion, composite materials, and new product development. David said his leisure activities center around the Andover Racquets Club and that he is "desperately looking for a cure for tennis elbow." Good luck, Dave. Earl is now in New Hampshire and is vice president of finance for the Frankie Foundation construction firm. David also wrote that another Course X classmate, **Al Morgan**, is with Cabot Corp. Al, like Dave, is a racquets buff with tennis, squash (along with deep sea fishing) taking up much of Al's spare time.

Howard Hornfeld is living in suburban Geneva, Switzerland, where he is a polymer consultant. Howie wrote that he is very active as actor and director in the "amateur (nearly professional) theater scene" and is also attempting to build a new theater complex in Geneva. . . . An article in the *Newport* (R.I.) *Daily News* noted that **George M. Walsh** was named assistant general manager of Raytheon's Submarine Signal Division. George has been with Raytheon since 1960.

I have the pleasure of seeing **Alan Starr** almost daily. Both Alan and I are in the Program Analysis and Evaluation Office of the Secretary of Defense. Alan joined our organization in 1986 after a number of years with the Department of Energy.

I'd like to urge you again to make your secretary's job easier by sending me a few lines.—**Frank A. Tapparo**, Secretary, 15 South Montague St., Arlington, VA 22204

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We have received a news release from the U.S. Air Force indicating that as of November 1, 1987, **Robert R. "Bart" Barthelemy** is managing the National Aerospace Plane Program, a joint Depart-

ment of Defense and NASA effort. In this capacity, Bart will head the research team that hopes to develop an aerospace plane that will be capable of taking off from a conventional runway, cruising into the upper atmosphere at over six times the speed of sound, and accelerating into earth orbit. The program is located at Wright-Patterson Air Force Base near Dayton, Ohio. . . . **Richard B. Anderson** writes that he has been recently appointed as director of research for a new medical research firm named Phase V Technologies, Inc. We also received a clipping from the Woonsocket, R.I., *Sunday Call*, indicating that **Herbert M. Taylor**, a resident of Framingham, Mass., is one of six prominent relocation specialists to found TransForce Relocation, based in Houston, Tex. Herb has been active with the Century 21 organization, and will continue to work with his own Century 21 Taylor Realty while he serves as vice-president of the new corporation. TransForce is a network of relocation specialists providing transferee referrals, education, training, mortgage organization and third party services to the real estate industry. So if your professional work requires a major relocation, you might want to check with our classmate or his new organization to give you a hand with the move.

More notes from the 25th reunion: **Douglas Dodds, Jr.** is working as a software engineer with Symbolics, Inc., in Cambridge, Mass. He and his wife, Lydia, have a 16-year-old daughter and are interested in music (as avid listeners), running, amateur astronomy, and gardening. Doug has been creating electronic-mail user programs at his firm, a pioneer in the field of network mail. . . . **Jon A. Davis** lives with his wife, Heather, and their three children in Rancho Palos Verdes, Calif. Jon is senior scientist with the Hughes Aircraft Co. in Torrance, Calif. . . . **Tom Brydges** served on the 25th reunion committee and attended the reunion with his wife Ellen. They live in Acton, Mass., with their two sons. Tom serves as director of technology with CTI-Cyrogenics in Waltham, Mass. Tom is active with the local Council of the Boy Scouts of America, and claims that his tennis is still improving. He reports that he is still searching for the right combination of events and ingredients that will allow him to bake the perfect croissant.

The P.O. Box (at least as personal as the answering machine) is still awaiting that flood of news from those of you with something to share with the rest of us. Please send news or even a card to:—**Hank McCarl**, Secretary, c/o McCarl and Associates, P.O. Box 352, Birmingham, AL 35201-0352

63 25th Reunion

It was a pleasure once again to hear directly from you. But let me first get a press release out of the way. **Mark Douma** is reported to be pursuing a J.D. at the Northeastern University School of Law. Some people start law school later in life. (I was almost 30.) But Mark must be at least 45. What had he been doing, and what motivated him to make this switch? Can any of you augment what I have learned? In any event, much luck, Mark.

Alan Schwartz says he only wrote this column once before, and his note never appeared. In behalf of my predecessors my sincere apologies, and thanks for having the persistence to write again. He says, "I never seem to recognize the names of the people whom you talk about, and so I sometimes wonder if indeed I went to M.I.T. But I guess I must have; else whey would they keep asking me for money?" An excellent question. Friends of Alan, confess your guilt. You must not be writing this column, because I am so desperate I print everything I get. (Confessions printed in this column will earn confessors special mention.)

Alan travelled from Tech to take Ph.D. in math at the University of Wisconsin at Madison, there meeting his wife April. He then joined the math department at the University of Missouri at St. Louis, where he has remained. (He and family have, however, taken sabbatical, most recently at Israel's Tel Aviv University.) Alan's son Aaron, 15, is a high school sophomore. And their daughter Alissa, 18, is now at college. Alan wants to attend our 25th reunion. So please help him. Answer his question: "Is there anybody out there I went to school with?"

Patricia Marzilli is a research associate in the chemistry department at Emory University in Atlanta. Her husband is there as Samuel Candler Dobbs Chemistry Professor. Their son Alan, is a high school senior, and is considering following Mom's footsteps to M.I.T. Daughters Vernonica, 15, and Alisa, 11, are as yet undecided. The family lives in Atlanta.

I have a fragmentary note from **Alan Schiudler**. He reports he practices pediatrics and pediatric endocrinology, and is married to a psychiatrist. They have three children, one a student at Wellesley College.

Late winter is a good time to remind you that our 25th reunion will be in June. It will be brief, just a few days, perhaps too short to become reacquainted with those you knew. We usually associate a college reunion with reminiscence. But that may be short-sighted. I was just looking through the list of '63 names in the M.I.T. Directory, and the names are legion. (Although my own name is not that common in the U.S., there is even another Phil Marcus in the class, and I never recall meeting him!) Many names I do not recognize. So perhaps the best reason to attend our 25th is not recollection but opportunity. Your classmates shared student experiences, have lived in similar times in history, and have similar employment and probably lifestyles. What better place to find people with whom to make wonderful new friendships? See you all in June!—**Phil Marcus**, Secretary, 2617 Guilford Ave., Baltimore, MD 21218, (301) 889-3890

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For those of us who worried about the effect of the October Wall Street tumble on our retirement plans, the following quote from classmate **Bob Scott** is offered, "This is going to be one of the most significant problems." Bob, who is a vice-president at Harvard, was quoted in a *Newsweek* article which discussed the impact of the stock market's drop on donations to universities.

Speaking of donations, the rest of the items this month are all from Alumni Fund contribution notes. Thanks to each of you for contributing and for sending along your news. **Lawrence Kaldeck** writes that he is still at Northrop Precision Products Division in Norwood, Mass., working on embedded microprocessor software. After seven years of doing that, he describes himself as "probably the oldest senior software engineer."

Bob Beardsley is busy trying to keep up his own science while serving as chairman of the Physical Oceanography Department at the Woods Hole Oceanographic Institute. (All those water fights at Baker House could have provided enough laboratory data for 20 years of research.) Bob and his wife Sue have two daughters. Liz is a senior at Stanford in civil engineering and Jean is a freshman at Duke in mathematics/physics. Bob notes that so far, he and Sue are enjoying the "empty nest."

Leo Cardillo offers a cryptic comment, "For those who know my work, this has been an interesting year to say the least!" His wife Bobbee is "tearing up the real estate market," daughter Laura is doing well in her junior year at Princeton and Frank and Eileen are fine as well.

Christopher Ritz is a partner in the firm of Ritz, Shapiro and Sipos (RSS) offering management consulting services in the area of decision support systems for production, inventory and logistics for marketing effectiveness. RSS has offices in New York and Boston. Christopher is living in Salem, Mass.

Louise and I are off to the Colorado Springs area for a week or so on a scouting trip. TASC will be opening an office there shortly and I have the responsibility of getting it going as a field location linked to my division here in the Washington area. Send your news notes, please.—**Joe Kasper**, Secretary, 3502 Idaho Ave., N.W., Washington, DC 20016

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Andy Tanenbaum writes that he's still professor of computer science at the Vrije Universiteit in Amsterdam Holland. During 1987, Andy published two new books and a software package, an operating system called Minix for the I.B.M. P.C. All three publications were huge successes. Andy says his 7-year-old son, Marvin, regularly beats him at chess, and he (Andy) hasn't decided whether he likes that or not.

Wayne Haase sent a note and clipping about his daughter, Katherine, who was one of 100 high school students to be a recipient in the Japan-U.S. Senate Scholarship Program. Katherine spent two months last summer living with a Japanese family. The Haase family lives in Los Altos, Calif. . . . **Dick Bator** sent a letter and mentioned that he's living in Burlington, Mass., and consulting in the Boston area. Dick says **Dan Diamond** is living in Groton and running his own management consulting business.

Finally, I regret to report that our classmate **Edward Shaw** of Arlington, Mass., died last August in an automobile accident in Pennsylvania. Ed had been an Arlington town meeting member, an active folk dancer, an avid sailor, and a member of the I.E.E.E. and Boston Computer Society.

It's November at this writing, and we just had our first snowfall of the winter. I hope spring's in sight by the time you read this.—**Steve Lipner**, Secretary, 6 Midland Rd., Wellesley, MA 02181

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Outside, the leaves are turning colors, and we have one of those beautiful Indian summer days. I suspect that when you read this you'll be hoping for spring to show up.

Peter Blankenship has been at Lincoln Labs since 1968. He is currently associate head of the Computer Technology Division. . . . **Richard K.N. Ho** has joined the Shui On Group, a major construction and property development group of companies in Hong Kong. He serves as executive director and managing director of its properties division. . . . **Dmitri Procos** has recently returned from sabbatical as visiting professor at the University of Paris (Sorbonne-Pantheon). He was listed in the 1987 *Who's Who in the World*.

A nice note from **David Wilcox** says that DCW Industries, which he founded in 1973, is going strong. He has also been teaching part-time at UCLA for the past five years, which he finds particularly enjoyable, using his 16.03 notes as the foundation for one of his courses! His daughter, Kinley, has just received her associate arts degree from Pasadena City College, exactly 20 years after our own M.I.T. graduation.—**Jeff Kenton**, Secretary, 7 Hill Top Rd., Weston, MA 02193

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I especially enjoyed a recent telephone call from **Ed Snyder** who was soliciting funds for M.I.T. I agreed to a contribution provided he sent me some news for *Tech Review*. Notwithstanding his comments regarding blackmail, a deal was struck. I later received the following news from Ed, and of course my check is in the mail. Ed reports that he served in the U.S. Navy after graduation from M.I.T. He is currently vice-president and general manager of TRW's Information Network Division in Torrance, Calif. Ed came to California for sun,

BRONZE BEAVER

The 1987 Bronze Beaver Award to Charles E. Kolb, Jr., '67, for "his extensive and diverse volunteer service to the Alumni Association and the Institute. His work on Alumni Association national boards and committees has been constant at every level, including membership on the Board of Directors. He has also supported sutdents as a member of the Visiting Committee for Student Affairs and as organizer of the Chemists Club, which serves as a model for alumni/ae relations with graduate students. We honor his depth and breadth of service to M.I.T."

fun and management and got all three. . . . **William Frangos** teaches math, robotics, computers and electronics at the Salt Lake Community College and provides geophysical consulting services during evenings and summers. His daughter Jennifer is a sophomore at Vassar. "Unlike her father, she did very well in her first year." . . . **Pat Confalone** is a research manager in Du Pont's Central Research and Development Department in Wilmington, Del., where he directs research efforts in bio-organic chemistry. He was recently named chairman-elect of the organic division of the American Chemical Society. Prior to joining Du Pont in 1981, Pat was a research fellow at Hoffman-La Roche. He has held teaching posts at Rutgers, the University of Colorado and Harvard. . . . **Pete Amstutz** is now living in Chicago after 12 years in Europe as an investment and commercial banker. He and his wife Heidi have two children, ages seven and five. Pete writes: "SOS. I would like to hear from any Chicago area classmates who can help me resettle in the real world. Daytime phone: (312) 236-5844."—**James Swanson,** Secretary, 878 Hoffman Terrace, Los Altos, CA 94022

68 20th Reunion

The first snow of the season is blanketing the Washington area as I write this. Washington is unprepared enough for snow when it comes in January, let alone November. Looks like it will be a long winter.

It may also be a slow winter, news-wise if we don't hear from a few more people soon. Our sources seem to have dried up. Only a couple of items arrived in the mail this month. Nothing last month. Perhaps the big fundraising campaign will restock our mailbox. So while you're giving money to the 'Tute, be sure to give some news to us.

The biggest news comes from Commander **Jack Rector**'s wife, Bonnie, who writes: "As Jack is too busy getting ready to return for the third time to the 'ice', I have enclosed articles about his assuming command of Antarctic Development Squadron Six (VXE 6) at Pt. Mugu, Calif. This year as he leaves in October for the five-month deployment, he won't be alone. Our daughter, Kimberly, is taking a year off between graduating from Concord Academy in Massachusetts and starting at the School of the Art Institute in Chicago. During this year she has been hired as assistant cook for the South Pole station! Our 16-year-old son, Jack (III), and I will stay behind and work on our tans!" The accompanying article, from *The Missile* at Pt. Mugu, describes VXE 6 as the air arm of "Operation Deep Freeze," a unique Navy squadron which maintains expertise in polar aviation while supporting scientific research sponsored by the National Science Foundation.

Robert MacDonald writes that he is "marveling at the phrase 'to err is human, but to really screw things up, you need a computer'." He hopes that the free-fall of 500 points off the Dow Jones the day he wrote ("obviously the result of some hard-working computers") will not screw up a private placement investment nearly ready to be offered. If it is successful, he will be a general partner after preparing the Offering Memorandum, and will oversee an investment in some technology with application to computer printers and monitors. Meanwhile, he thinks he should have enough time to add the partnership management to the business consulting he has been doing for the U.S. Air Force, which is converting the unit where he has been the Wing Standardization Navigator in C-130 aircraft to C-5 aircraft. "That's right," he writes, "the navigator has been replaced with a navigation computer."

Finally, **Fritz Efaw** writes that he was awarded a Ph.D. in economics by Rutgers University in 1987, and is currently assistant professor of economics at Vanderbilt University.

Our own news is that Gail has moved again within the Nuclear Regulatory Commission. She is now on the staff of commission Kenneth Rogers, providing technical and policy analysis and assistance. Commissioner Rogers, the newest appointee to the five-member Commission, is the former president of Stevens, another well-known Institute of Technology. He is beginning a five-year term on the Commission.—**Gail** and **Mike Marcus,** Secretaries, 8026 Cypress Grove Lane, Cabin John, MD 20818

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I'm writing these notes at the M.I.T. News Office, and it's just like old times. Down the hall a group of rag-tag Cambridge "tent city" people are camped out in the entrance dome, protesting their lack of shelter from the elements. But these are the 1980s—a distinct lack of tension in the air, despite the intruding campers.

An old 1960s Burton 4th rebel, **David Jodrey**, writes from deep in "rebel" territory, "Finally finished psychology Ph.D. at SUNY/Buffalo. Now teaching at Clinch Valley College in Wise, Va." Wisely, he adds, "The town name is an aspiration, not an accomplishment." . . . **Tim Casady** continues to work with the latest laser and ultrasonic equipment in surgery at St. John's Hospital in Santa Monica. He notes, "With the latest earthquakes, I have suddenly become interested in geology again!" . . . **Jeffrey Burke Satinover**, M.D., is the executive director and co-founder of the Sterling Institute, a new outpatient neuropsychiatric and behavioral medicine treatment facility in Stamford, Conn. He and his wife Julie live in Weston, Conn., with their six-month-old daughter, Sarah Katherine.—**Eugene F. Mallove**, 183 Woodhill-Hooksett Rd., Bow, NH 03301

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James F. Pelegano is presently associate professor of pediatrics at the Medical College of Wisconsin. He is also a neonatalogist working in the newborn intensive care unit of the Milwaukee County Medical Complex. He has three children and spends his leisure sailing on Lake Michigan. . . . **Paul Burstein** writes that everything is healthy and happy, business is great, and that, as president of a small business, he receives more junk mail than he thought imaginable.

Horatio Daub resides in Medford, N.J., and has studied and traveled around the world for the last three and a-half years. He has visited 46 countries. He is presently a board-certified family practice physician practicing in Mt. Holly. . . . **Monroe Benaim** is medical director of the Jupiter Eye Center, which is an ambulatory eye surgery center in Jupiter, Fla. Apparently this is the first such licenced facility of its kind in Florida.—**Robert Vegeler**, Secretary, Beers, Mallers, Backs, Salin and Larmore, 2200 Ft. Wayne Bnk. Bldg., Ft. Wayne, IN 46802

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H. DuBose Montgomery has been named to the M.I.T. Corporation. DuBose is a partner with Menlo Ventures, a venture capital firm in Menlo Park, Calif. . . . **Marc Roddin** writes: "My major professional responsibility is preparation of a new seaport plan for the San Francisco Bay Area. This entails land use controls to ensure that area will be available for needed marine terminal facilities in the year 2020. In the community, I'm completing a four-year stint as an assistant scoutmaster. My wife Barbi and I enjoy playing with our three-year-old son, Craig. . . . **Charles M. Koplik** sent in his name, but the news must have been separated from his information. Charles, if you write me directly I promise your information will make it in the Notes. . . . **Ronald G. Ort** is living in Boston and working as a patent attorney with the law firm of Cesari and McKenna.

Barney C. Black married Helena C. Dillon and honeymooned in the Dominican Republic. He ran into Fabio Guzman when he was there. . . . **Gus Kayafas** is the co-editor of *Stopping Time: The Photographs of Harold Edgerton*, published by Harry N. Abrams, Inc., 100 Fifth Ave., New York, N.Y. 10011. Gus is a research affiliate in Edgerton's stroboscopic light laboratory and is also the founder of Palm Press, Inc., an atelier that specializes in printing fine photography. He has published three limited edition portfolios of Edgerton's work.

The city of Brenham, Texas, is looking for start up or existing companies to locate in Brenham. The city offers some excellent incentives and this area is a great place to live. Call or write if you are interested.—**Hal Moorman**, Secretary, P.O. Box 1808, Brenham, TX 77833

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Steve Waller wrote a note I received the day after the killing of two servicemen at Clark AFB in the Philippines. He wrote that he was enjoying his assignment at Clark as an emergency physician; his wife Jane was busy as the ophthalmologist there. Steve wrote that his children Katie and Jeanie were enjoying themselves so much they wanted to extend their tour. I hope the recent events there have not touched the Wallers and all is back to normal there by now. Steve asked to pass along their address: PSC3, Box 16412 APO, San Francisco, CA 96432.

Rosalind Waldron is in a family practice unit at Waterville, Maine, after a three-year residency in Barberton, Ohio. And that's the way it is.

Down here where "R" doesn't get pronounced any more than in Maine, there's not much to report. The family's well, and I didn't have two

cents in the market when it crashed, so we're still making the mortgage payments. Write!—**Robert M.O. Sutton, Sr.**, Secretary, "Chapel Hill," 1302 Churchill Ct., Marshall, VA 22115

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Partners in crime, your news has been a little slow. Better write me a letter right now while you're thinking about it. Don't by shy! Wouldn't you like to see your name in print? Like, for instance, **Arvola Y. Chan,** who left Computer Corporation of America in August to join Lotus Development Corp. Or like **Robert Roth,** who was recently promoted to the tenured position of associate professor of mathematics and computer science at Emory University in Atlanta. Send me some news. It's fast, easy, does not promote tooth decay, and is approved for veterans.

A note from **Denny On Yat. Wang** reports that he has been a proprietor of Business Computer Systems Corp. in Hong Kong for the past ten years. They specialize in Chinese language computing. . . . **Lloyd Thompson** has returned to the Massachusetts area from Italy, where he was sales manager for GE Aircraft Engines in Italy, Yugoslavia, and Malta. Lloyd will now work as program manager for a new business jet engine joint venture with Garret Turbine Engine Co. . . . Susan and **Richard Hartman** were expecting their fourth child in October. The Hartman's live in Manchester, Mo.

The most interesting news note of the month comes from **Chuck Rosenblatt.** After seven years of research at the M.I.T. Magnet Lab, Chuck and family ahve moved to, of all places, Cleveland, where he is on the physics faculty at Case Western Reserve. Chuck says they had their misgivings about what they would find in "middle America" but find it quite livable and pleasant. For one thing, Cleveland is a friendly place to live. For another, housing is much more affordable than in the Boston area. And lastly, they've found a kosher Chinese restaurant! All the comforts of home. . . . Please note the new address of your faithful class secretary.—**Lionel Goulet,** Secretary, 115 Albermarle Rd., Waltham, MA 02154-8133

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Just a few items this time: **Evan Schwartz** has finished his training in orthopaedic surgery and is now specializing in sports medicine at the Catholic Medical Center of Brooklyn and Queens, N.Y. . . . Another of our medical classmates, **Lawrence R. Moss** is in the private practice of psychiatry and is presently in psychoanalytic training in Los Angeles, Calif. In his spare time, he's playing jazz piano in clubs around L.A.

Newsclips provided a major source of class news this month: From the *Daily Hampshire Gazette*, Northampton, Mass., **Taylor T. Dueker** of Maynard, Mass., has joined Architects, Inc. as a registered architect. He is a former associate with the Architects Collaborative, Inc., of Cambridge. He is a member of the Boston Society of Architects and the American Institute of Architects. . . . And from the *Times-Record*, Brunswick, Maine, **Brenda J. Schilinski** has been promoted to the rank of major in the U.S. Air Force. She is a special assistant to the commander for program management with the Air Force Geophysics Laboratory, Hanscom Air Force Base, Mass. . . . Finally, my favorite clip from the *Sunday Press*, Atlantic City, N.J., entitled "Winkers Brandish Squidgers at Ocean City Tiddlewinks Contest." **Larry 'Genghis' Kahn** is still winking after all these years. He still holds half of the world doubles title in tiddlywinks but lost the singles title at the world championship last year in Cambridge, England. (Good luck, next year). Aside from winking, Larry is an oceanic engineer who is helping to design a hovercraft simulator in Washington, D.C.

By the time you read this column I will be away at trial in San Jose, Calif., for an extended period. I am apologizing in advance if late in the year I skip an issue. Hope all is well with you and yours.—**Jennifer Gordon,** Secretary, 18 Montgomery Pl., Brooklyn, NY 11215; or c/o Pennie & Edmonds, 1155 Avenue of the Americas, New York, NY 10036

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We have some news from the mails. **Martin Deneroff** writes: "I am presently working at Concurrent Computer Corp. in Tinton Falls, N.J. My wife and I are the proud parents of Naomi Cheryl, who was born on June 15, 1986. We are expecting our second child in December."

Robert Dyson has managed to unseat an incumbent in Walpole, Mass., for a seat on the planning board. Judging from the newspaper clipping, it was hotly contested. Our congrats.

I had the pleasure a bit before these notes were due to have dinner in New York with **Mike Sarfatti**, who came in from Princeton, N.J. He is in Princeton for additional training in his new career as a stock broker with Merrill Lynch. Also at dinner was **Dan Dershowitz**. He is still with GAF.

As for your secretary, he has managed to flourish during the Great Crash. I have always had a fondness for the short side, as prices in all types of market tend to fall far faster than go up. However, I must confess that I was impressed with the carnage, even though I had seen panics in other markets before. Aside from the virtually unending turmoil in the financial markets in which I participate, life is good. My daughter continues to grow, as do my business interests. Please write. We sorely need the news.—**Arthur J. Carp**, Stalco Futures, Inc., 225 West 34th St., S. 1705, New York, NY 10122, (212) 736-1960

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As I write these notes, Washington D.C. is recovering from the biggest November snowstorm ever to hit this area. My 5-year-old daughter, Joia, was dismissed from school at 12 noon yesterday and arrived home at 6:05 p.m. That should give you an indication of how miserable it was here! Trusting that you are warm, dry, and snug wherever you are, I will catch you up on this month's news. . . . Leading off is the birth of Matthew Frederick Berg on October 7, 1987. Congratulations go to his proud parents, Christine and **Christopher Berg** of Holliston, Mass.

Jane Brown reports that her pediatric practice in Needham, Mass. is going well. Her son, Benjamin, who was 8 months old and crawling at the time of her writing, is a source of delight to her and her husband. . . . **Edward McKay** is now working as a communications scientist for Science Applications, Inc., in the D.C. area.. . . . **William Hadge** has been promoted to associate by Goldberg-Zoino & Associates, Inc., a geotechnical engineering/environmental consulting firm based in Newton, Mass.

We move from the East to the West Coast to catch up on our classmates. . . . **Stephen Gourley** and his wife, Kristin, are proud parents of a second child, Jonathan Ross Everett, born May 5, 1987. He and his big sister, Katie, are doing well. Stephen, still in the Los Angeles area, is preparing for a new assignment this summer, possibly in Denver. . . . I was delighted to receive a note from **Samuel Gasster** this month. Sam finished his Ph.D. in physics at UC/Berkeley in 1985, and he was married in April 1986. He and his wife, Diane, live in Los Angeles. Diane is an architect for a firm near Santa Monica; Sam works in the San Fernando Valley for a small R&D consulting firm.

That's a nice sampling from some of our Atlantic and Pacific based classmates—is there anybody out there in the middle? Wherever you live, we would love to hear what's new. Drop a note to me.—**Ninamarie Maragioglio,** Secretary, 8459 Yellow Leaf Ct., Springfield, VA 22153

CAMPAIGN

The Kick-off

Robert M. Metcalf, '68, entrepreneur and donor of an endowed professorship, spoke at the* Campaign for the future *kick-off in October.

His California-based company, 3Com Corp., which grosses more than $200 million per year, exploits computer networking technology that he first worked on at M.I.T. He described himself as being—at 41—"at an awkward age, about halfway between a rambunctious, razor-sharp student and a calm and wise alumnus." He said that his goal in the campaign will be to persuade other Silicon Valley-based alumni at similarly awkward ages to become early and strong supporters of the Institute.

He intends to lean hard on the "three G's"—guilt (at best, M.I.T. graduates paid only half the cost of their educations), gratitude (an M.I.T. background had a significant impact on the financial success of most of its alumni), and greatness (M.I.T. is a great institution; a continued involvement in its endeavors is very exciting) to motivate potential donors.

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Brian Wibecan writes, "Moved out of IBM VM support back to the world of VAX in spring 1987. Doing VMS performance analysis and capacity planning for various duPont sites. Singing with the Delaware Singers, a semi-pro 40-voice chorus." . . . **Jim Walker** is "still doing theatre in the Boston and New England area. I recently played Iago in 'Othello' at The Theatre at Monmouth, and can be seen in a very small part on ABC-TV's 'Spenser: For Hire'." . . . **Fred Berretta** is at Harvard Law School after 6 years with Hewlett Packard in San Diego. He will graduate in 1989.

Jeffrey Bloch writes, "The end of graduate school is finally in sight. By January 1988 I will have left Madison (Wis.) with my Ph.D. in physics and started a postdoc with an astrophysics group at Los Alamos National Labs." . . . **George Glackin** married Allison Haack last May 24 in the Long Island town of Massapequa. Classmates **Jan Kronish, Joe Dellorto,** and **Clark Bisel** were in attendance. Allison and George both work for Procter and Gamble in Cincinnati. . . . **Tom Cecere** graduated from Dartmouth with an M.S. in computer and information systems and now works as a software product manager for DTSS in

Hanover, N.H. At press time, Tom and his wife were expecting their first child on Thanksgiving Day. (Yes, believe it or not, I am writing this in November!). . . . **Robert Simms** is in Detroit doing computer and communications systems integration with EDS.

Barbara Biber writes, "Finally I'm nearing the end of radiology residency training at U. Mass.—five years after graduation from University of Rochester medical school. Watching my four sisters go through M.I.T. reminds me of how hard we all worked to earn our degrees—and earn them we did!" . . . This item from the *Middlesex News* (Framingham, Mass.): Captain **Ted Pounds** has participated in the Strategic Air Command's annual readiness training exercise "Global Shield 87." Ted is a pilot with the 529th Bombardment Squadron at Plattsburgh Air Force Base in New York.

This is a busy month for your faithful secretary. Earlier this week I started my new assignment with Mobil in the Office Automation Technology and Planning Department. I'll be working on a variety of projects involving PCs and office processors. After more than two years in the frantic pace of Operations, it will be a delight to exist in a more think tank environment. Also on my agenda—next week I open in my latest Off-Off-Broadway venture, a community theatre production of "You Can't Take It With You." I am playing the same part that I played with MIT Dramashop nine-and-a-half years ago—the one sane member of a very crazy family. As usual, I'm having a blast. Hope you are, too.—**Sharon Lowenheim,** Secretary, 303 E. 83 St., Apt. 24F, New York, NY 10028

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Happy Valentine's day and don't worry, Spring is just around the corner. (That's for those of us in northern climes who are waiting breathlessly for it!) For the second month in a row the Class of '80 mailbox was pretty much vacant. Needless to say, I'm expecting big things for the next few months! Please don't let me down.

Thomas Zimmerman wrote in from San Francisco to say that he invented a hand gesture input device called the Data Glove that appeared on the cover of *Scientific American* in October 1987. He's also trying to balance art with science by studying acting and the sitar. . . . **Darrell Hartwick**, in the meantime, is working for Schott Fiber Optics in Southbridge, Mass., designing medical inspection instruments. He lives in Brighton, Mass.

Two newsworthy items: (That means we received newspaper clippings about them!) First, **Kevin Riehl** completed the Air Force Institute of Technology (AFIT) program and received his master's degree in engineering physics. He is married to the former Dianne Segien. No news on where they're living, though. . . . **Diane (Gorczyca) Patrick** finished her residency in primary care internal medicine at Cambridge City Hospital, which is affiliated with Harvard Medical School. She has now joined the Truesdale Internal Medicine Associates of Fall River. I actually knew about this previously (just a little) when Diane and her husband Mike ('79) moved out of their condo (downstairs from mine). They have bought a house in Diane's hometown, which is down near Fall River. (Was the name of the town Apponequet?)

I've also received some news on Class of '80ers from people from other classes. Lawrence Siegel ('79) wrote to tell me about the wedding of **Walter Seale** to Michelle Bisagno. Joining in the celebrating were **Jim** and **Ann Kadonugo**, **Brian Torone**, Rober McSharry ('79) and Larry himself. Walt is finishing his residency in internal medicine at Stanford and will serve as the road manager for R.E.M. for one year before beginning a fellowship in cardiology at Cedar Sinai in Los Angeles. (Is that true??)

I also heard from a fellow Digital employee, Jonathan Griep ('81). Jonathan is married to our classmate **Martha Buck**. They have just moved back to the Boston area after spending about two years in Minnesota and three years in Maine (where they had both been working for Fairchild Semiconductor). Martha is now working for Honeywell Bull.

That's about it for now. Remember: I'm expecting big things (i.e., letters) for the next few months—at least!—**Kate Mulroney**, Secretary, 256 Hampshire St., #3, Cambridge, MA 02139

81

Ben Kerman is a medical resident at Mt. Auburn Hospital in Cambridge. He's been married four years to a woman who is eight years his senior, and they plan to adopt a baby soon. Ben writes that while future plans are uncertain, he is enjoying himself and his family. . . . **John Bisognano** received his Ph.D. in chemistry from New York State University (SUNY) at Binghamton in June 1987 and is now enrolled in the M.D. program at the College of Medicine, SUNY Health Science Center, Syracuse. . . . **Denise D. Denton** joined the faculty in the Department of Electrical Engineering and Computer Science at the University of Wisconsin in January 1987 after receiving her doctorate from M.I.T. She also was awarded a Presidential Young Investigator price from the NSF, which sponsors research up to $100,000 a year for five years. Congratulations.

From the *Union Leader* of Manchester, N.H.: **Stephen Skiest** has been appointed as a senior marketing specialist with M/A-COM Omni Spectra, Inc. Stephen graduated with an M.B.A. from the Kellogg School at Northwestern. . . . **Jan Saqib** graduated from the Wharton School in December 1985 and is working as a product manager at Sun Microsystems in Mountain View, Calif. . . . **Richard Park** is still working as a management consultant at Pugh-Roberts Associates in Cambridge, Mass. He is the proud father of a son, Benjamin Maxwell. Congratulations. . . . **Dave Goldberg** is living in Manhattan and has been working since 1985 as an associate research scientist at Lamont-Doherty Observatory and as a consultant in geophysical methods in groundwater pollution control in the Metropolitan New York area.

I received several pages of information from **Marc Chelemer,** who keeps in touch with many of our classmates. Marc reports that **Glen Katz** is living and working in Cupertino, Calif. Glenn is active in the M.I.T. Club of Northern California and is editor of the club's newsletter. . . . **Sally Wolford** is working for Amoco Corp. in their Whiting, Ind., production plant. Sally lives in Chicago and wakes at 5 a.m. in order to run before work. She completed the M.B.A. program at the University of Chicago. . . . Marc learned through Sally that **Catherine "Wizzy" Markham** lives in Philadelphia with her husband George.

Best wishes go out to **Marc Stutman** and his brother Steve, '79, who have started a venture—manufacturing equipment and software for the telecommunications and paging industry. Marc is living in Cambridge and working very hard. . . . **Barbara Masi** is working for the new M.I.T. Commission on Industrial Productivity, studying the way that U.S. steel companies work with the automotive industry. Barbara completed her M.S. in materials science last year at M.I.T.

Ephriam Fuchs, M.D., is a resident in internal medicine at Johns Hopkins in Baltimore, after completing medical school at the University of Pennsylvania. . . . **Rob Worthingham-Kirsch,** M.D., is living in the Philadelphia area where he is a second-year resident in diagnostic radiology at the Mercy Catholic Medical Center in Southeastern, Pa. Rob and his wife Kimberly have two daughters, Cathryn, 2, and Connie, 1, as well as many pets.

Marc saved the big news for last. He was married on November 1 to Carol Shansky (master of music, Boston University, 1986). They honeymooned in St. Martin and had a great time. Con-

gratulations. Marc is a senior liaison officer with the Industrial Liaison Program at M.I.T. He's been there almost three years, and his duties involve working with oil and gas companies worldwide. In fact, Marc's job has taken him to Israel, Sweden, Finland, Norway, Germany, France, and England.

I had dinner earlier tonight with **Evelyn Jacobson,** who was back East for the Thanksgiving holiday. Evelyn's still living in Santa Clara, where she works as a packaging engineer for LSI Logic. She was happy to be back visiting but said that she does not miss the weather one bit.

On to the missing classmates file. This is your opportunity to inquire and learn about some of our less communicative classmates. This month's file includes: **Stephanie Ackee, Steven Alexander, Dalit Ashany, Carl Awh, Mike Barrett, Neal Berger, Andrew Cohen, Laura Dugan, Joel Foner, Mark Hellinger, I-wen Huang, Don Johnston, Jenny Kish, Deborah Meadows, Wendy Myers, Amelia Phillips, Ruth Salomaa, Alfred Spencer, Dorothy Tsang, Neng Hui Wang, Michael Zelin.** Please let us know what these classmates are doing and send in your requests for information on other missing classmates. Have a nice rest of the winter, and please write.—**Lynn Radlauer Lubell,** Secretary, 216 Beacon St., Boston, MA 02116

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A recent dim sum brunch in New York City with **Alison Kutchins** produced all sorts of interesting class news. Alison is a vice-president at Goldman, Sachs; she helps technology companies raise money. Alison reports that two of my fellow lawyers, **Emily McMahon** and **Guy Petrillo,** are working at the New York offices of Davis, Polk. Guy mentioned to Alison that **Barry Cheskin** is at Columbia Business School.

Other news from Alison: **Beth Klerman** finished a Ph.D. at Harvard Medical School in the spring of 1987 and thereafter resumed her last two years of medical school. . . . **Mark Schmaier** is back in Boston doing venture capital work after finishing at Stanford Business School. . . . **Raj Sinha** finished both medical school and business school at the University of Chicago, decided not to torture himself with medical residency and is working at Saloman Brothers in New York.

Karen Perizzolo reports that she married Joel DiMatrox, '79 (Sloan '84) last May; **Mary E. David,** Aline McKenzie '83, Chris Icklee '79, Bill Hilliard (Sloan '84), and Brian Sullivan (Sloan '84) stood up with them. Karen is an intern in medicine at Stanford Hospital and Joel has founded a small start-up company.

I am saddened to report the death of a classmate, **Glenn W. Parker.** Glenn, a member of Kappa Sigma, died last July in a hit and run accident with a motorboat on Long Pond in Harwich, Mass., where his parents live. Glen had been a systems engineer with A.P. Labs in San Diego, Calif. since 1985.

Please be patient if you've written since the class notes column began anew last fall. There is a long delay before publication—this column was written in mid-November! If you want to keep seeing class news, drop a line to East Coast correspondent **Linda Schaffir** (18 Prospect Ave., Apt. B-2, Norwalk, CT 06850); West Coast correspondent **Michelle Gabriel** (656 S. Fair Oaks Ave., D-211, Sunnyvale, CA 44086) or me.—**Stephanie Pollack,** Secretary, 33 Trowbridge St., Cambridge, MA 02138

84

I can no longer say that no one has written me since I just got a letter from **Dennis Sacha.** Thank you very much, Dennis!! Not only did he write to tell us about the comings and goings in his life, he also wrote about quite a number of other people in the class of '84. He says: "I received my wings (navy pilot) on August 21 despite failing vision and a metal arm. I am currently assigned to fly A-6s out of Oceana, Va. . . . **John Einhorn** received his wings in April and is also here at Oceana flying F-14s. John married Laura Childers in June. . . . On my way from Texas to Virginia, I visited **Carl Adams,** who works at Johnson Space Center in Houston. He said to write to your congressman and tell him to cut NASA funds since they waste too much money. . . . I also saw **Kim Coldwell** in Houston. She still works for a five-person company making sensors for chemical plants. . . . Currently, I am in the middle of a bridge game by mail with **Dave Walter, Howard Reubenstein,** and Ailish O'Connor. Dave works for Boeing in Seattle along with **Jeff Berner** and **Ann Clausen Berner.** Jeff and Ann just bought a house in Seattle. Howard lives in Boston and is working on his Ph.D. in electrical engineering. When he is not a nerd, he spends his time with Lori Brill. . . . Lori Brill shares a house in Somerville (and I hope I get this right) with **Chris Craven,** who is back at M.I.T. working on another degree.

"I was in New York and stayed with **Brett Hildebrand.** Brett still works for Goldman Sachs. Brett and I did a tour of bars on 3rd Avenue. It must have been successful since all we remember is the hangover."

As for some other news that I received from M.I.T., **Alison Taylor** has just started grad school at Harvard School of Public Health studying environmental science. . . . **Barry Surman** has joined the presidential campaign for Paul Simon.

I also ran into some old class of '84s from Burton House—**Gil Ettinger** and **Linna Wu.** They are now in Sunnyvale, Calif., and plan to get married next year (congratulations!). Linna is working for Lockheed, and Gil is working for a small AI firm here in Silicon Valley. They told me that **Glenn Barest** and **Howard Gordon** are in medical school in Cincinnati. . . . Also, **Julie Goddart** is expecting a child in the spring of '88. Good luck on the delivery.

Thanks for all the news. Hope you all had a nice holiday season.—**Mona Wan,** 10480 Creston Dr., Los Altos, CA 94022

85

Okay, Okay, we changed our minds. . . . Jeff and I are staying in the States. We decided that California is a nice place to live, so nice that a number of Japanese are moving here! It is expensive to live in Tokyo—rents are similar to New York City and groceries are three times as much.

Roy Peterkofsky received a Master of Engineering in transportation from University of California/Berkeley last spring. After spending his summer backpacking through Europe, he joined the research and test department of the Association of American Railroads in Washington, D.C. He has been spending some of his free time running on the Mall, populating the 9:30 Club, and preparing to present a paper at the Euro-TIMS Conference in Paris this summer.

Danielle Sherwood is working for Goldman Sachs in New York City and has a beautiful apartment on the upper west side. . . . **Joyce Chung** works for a Cambridge firm and shares an elegant Marlborough St. apartment with some Alpha Phis. . . . **Joyce Lee** just returned from a three-month trip to China on a M.I.T./Harvard traveling scholarship. She is now working on a Master of Architecture and a M.S. in real estate development at the 'Tute. . . . **Diane Hess** moved in with **Kathleen Harragan Harvard** for a year, working on her graduate degree in architecture. She is still going strong with PBE brother **Henri Lesez.**

I know you dudes are up to something so drop me a line!—**Stephanie Winner,** Secretary, 1026 Live Oak Dr., Santa Clara, CA 95051

86

Happy Thanksgiving! Just wanted to give you a feel for how much lead time there is between

writing this column and publication. I received lots of letters this month. Keep up the good work.

Lee Newberg has taken leave of the Princeton University Mathematics and Physics Department to do computer programming for Microsoft Corp. in Seattle, Wash. In between, Lee's found time to climb Mt. St. Helens and attend the David Bowie concert. . . . **Vic Christensen** is now at Keesler A.F.B., M.S. training to be a communications/computer systems officer. He will head north in mid February to Wright-Patterson A.F.B., Ohio, to put his training to work. . . . **Debbie Zappen** is at UC/Santa Barbara finishing her master's in electrical engineering. . . . **Rick Feinleib** is at the University of Arizona in Tucson at the Optical Sciences Center. One of his roomates is Yueh Chuang, '83. Rick is still deciding on whether to finish up with a master's or go all the way with a Ph.D.

Carolyn Beer sent me a letter from Champaign, Ill. Things are going pretty well—she's got a good internship and will be getting her master's of architecture and M.B.A. in June. . . . **Kathy Kim** is also there working on an advanced degree in mechanical engineering. . . . **Rich Maurer** stopped by to see Carolyn on his way to Lubbock, Tex. Rich is really enjoying learning to fly aircraft for the air force.

Suzanne Dunbar writes from Houston, Tex. She's still working for Interox-America, subsidiary of Solvay & Cie of Belgium. She is being transferred to Brussels in early December to work for Interox Coordination. . . . **Ray Brunsberg** is there working for Soltex, another Solvay company. . . . Bob Struble, '85, and Dave Karohl, '85, also work for Interox. . . . **Lo-Puig Yeah** is yet another Soltex employee and is spending time in Italy. . . . **Mary Bayalis** is engaged to be married on May 28. . . . **Gabrielle Hecht**, **Ginny Agresti**, and **Lauren Singer** will all be in the wedding party along with Suzanne. Gabrielle received a National Science Foundation grant and is still working on her Ph.D. in history of technology at University of Pennsylvania. Ginny has just left GM to take a position with 3M in Columbus, Ohio. Lauren is still owner of Think Consulting, a software firm in Ft. Lauderdale. Mary will reside in Los Angeles after graduating from Berkeley in December.

James Person and **Jon Athow** are both in San Diego doing "all that great navy stuff." . . . **Bill Hobbib** has settled for the time being in the Chicago area. . . . **Ed Mount** is also in Chicago.

Second Lieutenant **Andy Peddie** arrived for duty with the 1000th Special Operations Group at Fairchild A.F.B., Wash. Andy is a space operations crew commander. . . . **Carlo Zaffanella** works at GE in the Ordance Systems Division and is pursuing a master's at Rensselaer Polytechnic Institute. . . . **Win Treese** is working as chief systems engineer for Project Athena at M.I.T. . . . **Doug MacLeod** married Heidi Harkins from Harvard University in August. Doug is employed by Applicon in Westford, Mass.

Chris DaCunha was out in Los Angeles a few weeks ago on business. He works for Hutchinson & Co. Chris is planning a trip back home to Nairobi, Kenya, in December. . . . **Karl Tucker** came up to Los Angeles from San Bernardino, Calif., where he is stationed at Norton A.F.B. We got together with Arnie Burke, '85, and Gary Wyetzner '85. Arnie is employed by McDonnell Douglas in Long Beach, Calif., and Gary works at the Aerospace Corp. in El Segundo, Calif.

I spent last weekend in Oregon attending the Stanford and Oregon State University football game. I finally found another school with the beaver as a mascot. OSU has more beaver paraphernalia than we do.—**Mary E. Cox**, Secretary, SD/CLTPC, P.O. Box 92960, Los Angeles AFB, CA 90009-2960

87

Can you believe that it's been almost a year since we were planning for our last Spring Breaks? A lot of plans must have changed since then; write me a letter and tell me all about it.

I've heard from some classmates still in the area. **Phyllis Kristal** is working for Candela Laser Corp. in Wayland, and **Greg Troxel** is an M.I.T. graduate student working at Draper and living in Ashdown. He told me about some of his friends: **Karen Voss** is working for NorthWest Orient in Minnesota, and **John Burroughs** is working for Lotus and living in the Boston area; **Janice Onanian**, and **Yang M. Tan** are 6-3 graduate students at M.I.T.

Mike Caleo is leaving his software engineering job in Boston soon to travel to the South Pacific for four to five months. He plans to return to the States in time to start law school in September. Mike gave me a run down on some of his fraternity brothers. **Stan Huang** (Lotus), **Al Nikololich** (Raytheon) and **Tony Hu** (IBM) are all living in the Boston area. **Derek Aqui** is now a mechanical engineering graduate student in sunny California, and **Chih-Ming Chiang** is studying bio-medical engineering at the University of Michigan. Finally, **Tom Spahr** and **Jeff Morse** are living in Maryland and working for Booz Allen & Hamilton.

From my Fiji connection, Hugh Ekberg ('88), I found out that **Brett Giles** is living in Erie, Penn., and working for the Lord Corp.; **Glen Hopkins** is working for Texas Instruments in Dallas; and **George Zacharey** is working for Strategic Planning Associates in Washington, D.C. On the military front, **Mike Donahue** is in Alabama with the U.S. Army, and **Steve Brown** is in Lexington, Mass., with the Air Force. **Aurelio "Augie" Peccie** and **Chuck Thompson** have started their own company building houses on the Cape.

Last Thursday night, on yet another trip to the Thirsty Ear, I saw **Eugenie Uhlman**. She'll be finishing up at M.I.T. in December and heading to graduate school at the University of Arizona. Her boyfriend, **Matt Denesuk**, and **George Dale ("Buzzy")** are already students at the University of Arizona studying material science and engineering. Another Arizona resident, **Eric Bettez**, is working for Intel in Phoenix. Eugenie told me about some other classmates. **Mike Esposito** and **Mike Decalvacante** are both living in New York and working for ToucheRoss; **Nikoletta Fouska** and **Jim Brennan** are both 6-1 graduate students at M.I.T. (Jim is still living at the Beta House); and **Jennifer Buchner** is a computer science graduate student at Johns Hopkins University. (She's still following the Yankees, and Eugenie says she's been dating one of their pitchers.) **Mimi Ing** is a 6-A coop student at Genrad Co. in Weston, Mass. She'll be married on June 11 in Vermont to Frank Slaughter ('85). **Connie Perrier** is working for an actuarial firm in Fort Lee, N.J., and living with **Debbie Bontempo** (Columbia Law School).

I talked with **Tim Lash** and got an update on some classmates from ATO. Tim is doing toxicology and environmental health consulting for Meta Systems Inc. He's living with **Rich Chleboski** (Mobile Solar) in Billerica and **Steve Hunter** (Wyatt Agency) in Waltham, Mass. **Norman Chen**, working for the Mac Group in Harvard Square, is living in Wellesley, Mass. **Joe Papalia**, working for Lyccoming, is living in New Haven, Conn.; and **Chris Andrysiak** is working for Goldman Sachs (real estate investment) in New York City.

Now for a special Class of '87 athletic update. This past Class Day there was a Class of '87 boat in the Senior Eight Division. Special correspondent and team member, **Alan Gordon**, reported that the boat most likely would have won had it not been for an unfortunate crabbing. Team members included **Brian Barth**, **Mike Keirnan**, **Rod Moreno** (all finishing their studies at M.I.T.), **Steve Brown**, **Matt Healy** (chemistry graduate student at Harvard), **Lorenz Muller**, and **Dave Jeserum**. **Stan Oda** was coxen.

That's it, I'm signing off for now but I'm going to need your help on the next one. Write.—**Stephanie Levin**, Secretary, 3201 Eighth St., Charlestown, MA 02129

COURSE NEWS

I CIVIL ENGINEERING

Major honors came to four alumni during the 1987 ASCE annual meeting in Anaheim, Calif.:
☐ To **Ray W. Clough,** Sc.D.'49, Nishkian Professor of Structural Engineering, emeritus, at the University of California at Berkeley, the Norman Medal for a paper on tubular steel offshore towers, of which Clough was co-author, in the *Journal of Structural Engineering*.
☐ **Leonardo Zeevaert,** S.M.'40, professor emeritus at the National Autonoma University of Mexico, was 1987 Terzaghi Lecturer; his topic: the dynamic response of ground and building foundations during the 1985 Mexico City earthquake.
☐ To **James C. Howland,** S.M.'39, senior consultant at CH2M HILL, Corvallis, Ore., the grade of honorary member in ASCE for "contributions to the profession in management and excellence in engineering."
☐ To **John Parmakian,** '30 (II), the Rickey Medal "for his illustrious career related to the design of hydromechanical equipment for hydroelectric projects and for his significant contributions to the literature on waterhammer phenomena."
From **Joseph J. Rixner,** C.E.'68, Fairport, N.Y.: "Currently am partner of H & A of New York, Rochester, managing all activities of the office, which include geotechnical engineering, geology, and hydrology. The office is an affiliate of Haley & Aldrich, Cambridge."

Charles E. Carver, Jr., Sc.'55, reports his retirement to become professor of emeritus of civil engineering after 31 years of service at the University of Massachusetts, Amherst. . . . To **Samuel Davis,** S.M.'39, of Saint John, N.B., the honorary degree of doctor of laws from the University of New Brunswick.

Neil S. Shifrin, Ph.D.'80, is cofounder and principal of Gradient Corp., Cambridge, an environmental consulting firm specializing in chemical transport and health risk assessment. . . . **Stuart A. Freudberg,** S.M.'77, Falls Church, Va., is currently director of the Department of Environmental Programs for the Metropolitan Washington Council of Governments. . . . Lehigh University president **Peter W. Likins,** S.M.'58, has been elected to the Board of Directors of COMSAT, the Communications Satellite Corp. **M. Hamdy Bechir,** Sc.D.'63, of Guilford, Conn., received the Charles Alvin Emerson Medal of the Water Pollution Control Federation late last fall; Bechir is professor of civil and environmental engineering at the University of New Haven.

II MECHANICAL ENGINEERING

Major new responsibilities for **Samuel M. Tennant,** '50, formerly Programs Group vice-president at Aerospace Corp., El Segundo, Calif.: he is now the corporation's president and chief executive officer. Aerospace is a nonprofit company providing architect-engineer services to the U.S. government, chiefly the Air Force Systems Command.

Other new appointments in the news: **Robert G. Foster,** S.M.'63, formerly president of Ventrex Laboratories, Inc., Portland, Me., is now director of the Innovation Center of the Massachusetts Biotechnology Research Institute, Worcester, Mass. . . . Formerly chief engineer for production engine development at General Motors' Detroit Diesel Allison Division, **Daniel M. Hancock,** S.M.'73, is now chief engineer for advanced powertrain systems at Chevrolet-Pontiac-GM Canada Group. . . . **William Kyros,** S.M.'57, of Dracut, Mass., has been promoted to professor of plastics engineering at the University of Lowell (Mass.). . . . At General Electric since 1979, **Norman Z. Shilling,** S.M.'67, has joined the GE Research and Development Center, Schenectady, as R&D analyst.

Given the quality of its drivers, is a wedding of bicyclist and motorist thinkable in Boston? It's the dream of M.I.T. Professor **David Gordon Wilson** of M.I.T. as chairman of the Safety Committee of the Boston-Area Bicycle Coalition. Wilson is described by *Tech Talk* as "M.I.T.'s bicycle safety guru," and the wedding ceremony is the theme of the committee's posters promoting greater courtesy and respect for traffic laws on the part of both bicyclists and motorists.

An update from **William L. Verplank,** Ph.D.'77: ". . . proud papa of Jansen (age 5), happy husband of Dolly (since 1981), singing bass in the Baroque Choral Guild, and living in Menlo Park. After seven years testing and designing computer-user interfaces with Xerox, am consulting through ID TWO in San Francisco and teaching part-time at Stanford."

In a prideful letter for which he need make no apologies, **John V. Solomon,** S.M.'62, writes from Glastonbury, Conn.: "Son, J. Matthew, graduated from M.I.T. last year, also Course II; was three times soccer MVP, co-captain and All-New-England his senior year, and received Straight T Award." . . . **Victor S. Aramati,** S.M.'71, writes from Sudbury, Mass., that he is manager of quality and reliability for DEC's semiconductor operations. . . . **Guido Danieli,** Ph.D.'76, leads a busy life in Milan, Italy: he is currently managing director of a distribution firm, active in research and development in the medical field, and a university faculty member. . . . In Rockford, Ill., **Patrick J. Dulin,** S.M.'69, is responsible for the brushless d-c motors produced by Pacific Scientific Motor and Controls, of which he is vice-president and director. . . . **Steven F. Manzi,** S.M.'77, continues as senior project engineer at Apollo Computer, Inc., Chelmsford, Mass.

Dominique J. Leroux, S.M.'74, reports from Saint Herblain, France, that he is assistant director of engineering for Rockwell Systemes Graphiques in Nantes, a subsidiary of Rockwell International making offset rotary presses for newspapers. And **Kurt Goldmann,** S.M.'46, formerly chief engineer at Transnuclear, Inc., White Plains, N.Y., reports his 1987 retirement.

Addison V. Dishman, S.M.'40, retired with the rank of colonel from the U.S. Army, died in Cocoa Beach, Fla., on July 25, 1987, and **George A. Zeller,** who held the rank of lieutenant colonel, died in St. Louis on October 14, 1987.

III MATERIALS SCIENCE AND ENGINEERING

Two major prizes in the major international competition in metallography for 1987 went to four staff members at Oak Ridge National Laboratory, among them **John Vitek,** Sc.D.'68. Vitek, at ORNL since 1980, is a member of the microscopy and microanalytical group. He and his colleagues were co-authors of a technical paper on the analysis of stainless steel welds; they won the Pierre Jacquet Medal of the International Metallographic Society and the Lucas Award of the American Society for Metals.

A tantalizing note from **Stefan H. Garvin,** S.M.'50, arrived late in the fall: "I am just about to leave for another trip to the Orient . . ." Now that he's back, a further report would be welcome.

IV ARCHITECTURE

The office of **Theodore Mariani,** S.M.'57 (I), in Washington was the site late last fall for a gathering of Washington-area architecture alumni. The program: descriptions by Mariani and **Rosemary Grimshaw,** M.Arch.'78, lecturer at M.I.T., of current developments and issues in building and land preservation. Mariani's office was exhibit one—a "highly successful" addition (in the words of convener **Julius S. Levine,** M.C.P.'60) to a historic building just off Dupont Circle in Washington.

Roderick T. Freebairn-Smith, M.Arch.'61, who manages Freebairn-Smith Associates in San Francisco, has a full agenda; he writes, "Currently a trustee of the Urban School of San Francisco developing a building capital fund program, a member of M.I.T.'s visiting committee for the Libraries, and the mayor's appointee to represent downtown residents in a replanning effort for Fisherman's Wharf and the northern waterfront of San Francisco."

And **Donna P. Duerk,** M.Arch.'80, has an equally busy program: she is vice-chair of the San Luis Obispo (Calif.) Planning Commission, busy with developing public arts projects and researching the effects of computer technology on office environments, and teaching two courses (design studio and architectural programming) at California Polytechnic State University, where she expects a faculty appointment soon.

Too late to encourage readers to view it, we learn that the work of **Shelly Lake,** S.M.'79, a computer artist whose headquarters are in Los Angeles, was exhibited at the Photographic Resource Center, Boston, late last year and into January. Other of her work was showing at the same time at the Laforet Museum Harajuku in Tokyo, and Lake was a recent winner of an AT&T computer art contest. . . . Another "too-late" notice from **Leah P. Greenwald,** M.Arch.'78, who has a private practice in Cambridge: she expected to be on television as a Jeopardy contestant during the second week in January.

Nezar Alsayyad, S.M.'81, writes that 1987 was

A Three-Pronged Thrust Toward More Affordable Housing

A women's shelter of three linked houses to "merge with the rest of its Roxbury neighborhood" has won the AIA prize for four M.I.T. graduate students, Pablo Luna, Daniel Glenn, Neil Mongold, and Laura Spark.

Housing for the homeless and low-income families attracted special attention in the School of Architecture and Planning last fall. A team of M.I.T. graduate students copped first place in a regional competition of the Boston Society of Architects to design housing for the homeless, grants of just under $250,000 came to M.I.T. for publication of studies on the much-debated federal role in affordable housing, and the Center for Real Estate Development (CRED) announced major new research on the issue of affordable home ownership for low- and moderate-income people.

The graduate students' assignment was to design a shelter for 12 homeless or next-to-homeless women and their children. In addition to housing, there were to be common rooms and office space for staff who would help the residents find permanent housing and financial support.

Daniel J. Glenn spoke for his teammates when he told *The Tech* that the project was "a tremendous opportunity to work with homeless issues. I learned a lot. . . . That's actually one role of the competition—to broaden the public's knowledge of the problems of housing the homeless."

He described the students' solution: to break up what might be a very large project, he said, "we divided it into three distinct triple-decker houses connected only on the first floors."

The federal role in housing will be the focus of 19 papers commissioned from outstanding experts under the foundation grants. Each will discuss present national policy on one aspect of the problem, how that policy is working, and what might be alternatives. The papers will be published informally next spring and soon thereafter in an edited volume. Professors Langley Keyes, Ph.D.'67, and Denise di Pasquali, Ph.D.'79, of the Department of Urban Studies and Planning are in charge.

Three areas will receive special attention in the CRED project—mortgage assistance programs, housing design and production, and concensus building for the acceptance of neighborhood low-income housing.

"There is an expectation on the part of most Americans that at some point in their lives they will be able to buy a home," says James McKellar, director of CRED. But he thinks that "for many the prospects of fulfilling that expectation have been greatly diminshed in recent years." The study will evaluate this proposition and suggest ways to solve the problems of low- and moderate-income would-be homeowners. □

"a very productive year. In addition to my regular teaching duties at Berkeley," he reports, "I received grants from the Graham Foundation and the National Endowment for the Arts to conduct an international conference on traditional dwellings and settlements across the world to be held at the University of California at Berkeley in April 1988. I am pleased to report that among 120 accepted papers, 20 are by former and current M.I.T. colleagues." . . . A similarly optimistic report comes from **Kurt Eichenberger,** M.Arch.'82, in Raleigh, N.C.: "Will soon begin our third year of private practice with a library for Wake County, N.C. Business continues to be good and the challenge rewarding." **Joan K. Safran,** S.M.'80, has been named by Forest City Development to be director of community relations for University Park at M.I.T., which will occupy the so-called "Simplex" site northwest of the Institute.

V CHEMISTRY

The reference in *Technology Review* for August/September *(page 20)* to work on chemiluminescence by **Nien-chu Yang** of the University of Chicago brought a nostalgic note from Yang, whose name was misspelled in the *Review*'s report: "For many years my wife, **Ding-Djung H. Yang,** Ph.D.'55, was the Educational Counselor for M.I.T. for the south side of Chicago and interviewed scores of applicants every year. I met her at M.I.T. when I was a research associate working in the laboratory of Professor **George H. Buchi** for more than two years starting in November 1952. We have many fond memories of walks along the Charles River and of Buildings 2, 4, and 6 . . ."

Joel A. Silver, Ph.D.'76, is cofounder and vice-president of Southwest Sciences, Inc., Santa Fe. . . . **Gary S. Calabrese,** Ph.D.'83, is principal scientist with Instrumentation Laboratory, Inc., Lexington, Mass; for two years after receiving his doctorate he was with Polaroid Corp.

From **Elana B. Doering,** Ph.D.'86, Brookline, Mass.: "I am still at the Institute, now in my second year in the Harvard-M.I.T. Division of Health Sciences and Technology—the joint M.D. program with Harvard Medical School. I have also been working on physiology software planning with M.I.T.'s Project Athena and on comparative respiratory physiology with Harvard's Concord Field Station/Museum of Comparative Zoology." . . . From the Chemistry Department at Georgia Southern College, Statesboro, **Robert N. Nelson,** Ph.D.'69, reports that he spent the first half of 1987 on sabbatical at Goddard Space Flight Center studying cosmic dust.

The death of **David A. Johnson,** Ph.D.'52, of Fayetteville, N.Y., on September 8, 1987, is reported by his widow, Merece Johnson. At the time of his death Johnson was vice-president of development, Industrial Division, of Bristol Myers, Syracuse, having been with the company for 35 years. The deaths of two classmates who received doctorates in 1948 have also been reported: **Edward L. Brady,** Ph.D.'48, of Chevy Chase, Md., formerly associate director for international affairs at the National Bureau of Standards, on September 20, 1987, and **Philip H. Towle,** Ph.D.'48, of Naperville, Ill., retired from Standard Oil Co. (Indiana), on May 6, 1987.

VI ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

The 1987 Microwave Career Award, the highest honor of the Microwave Theory and Techniques Society, was given to **Robert W. Beatty,** S.M.'43, in Las Vegas last June 10. He was cited for "a career of meritorious achievement and outstanding technical contribution." Beatty, who now lives in Boulder City, Nev., holds a doctorate (1972) from the University of Tokyo, given during the 26-year period of his employment in the field of microwave standards at the National Bureau of Standards, Boulder, Colo. Since retiring in 1974, Beatty has been a consultant and lecturer and is now associated part-time with Barth Electronics Co.

PHOTO: DONNA COVENEY, M.I.T. NEWS OFFICE

VI-A Internship Program

Over the years it has been interesting to observe how many companies return young VI-A grads to the campus to handle their recruiting. It has been gratifying to have many of these alum's visit the VI-A Office to renew their acquaintance and update us on their lives. Over time we get a wonderful perspective on how our grads end up using their education and of the ultimate diversity of their activities. It has, indeed, been an inspiring experience.

William B. Lenoir, Ph.D.'65, is an example. As a NASA astronaut he flew in *Columbia* and presented the VI-A Office with a color photo of its lift-off. His notation on the photo reads: To the VI-A Program, with thanks for helping me get ready for this. Best Wishes. Bill Lenoir. This fall Bill was back on campus presenting a recruiting lecture on the technology centers of Booz, Allen, & Hamilton, Inc. with whom he is a principal in charge of the space systems practice as applied particularly to the manned space station program.

In Boston for a conference, **Steven K. Ladd,** S.M.'81, arranged a luncheon date with your correspondent. Steve is currently with Raychem Corp. of San Jose, Calif., and has done campus recruiting in the past.

At the fall 1987 VLSI research review of the M.I.T. Microsystems Research Center, Professor **Paul L. Penfield, Jr.,** presiding, three graduate students (former VI-A'rs) were among those presenting papers: **Henri J. Lezec,** S.M.'84, **Ghavam G. Shahidi,** E.E.'84, and **Jon P.Wade,** E.E.'85.

At the VLSI Review I had the pleasure of meeting **Kathleen Early,** graduate student in Course VI, who is the daughter of James M. Early. Dr. Early served as VI-A Co-ordinator at Fairchild Palo Alto Research Center for a number of years until his retirement this past summer. He was director of research and development at Fairchild, and he and his wife were frequent attendees at our VI-A West Coast picnics.

Just after Thanksgiving Professor **David F. Tuttle,** Sc.D.'48, of Stanford's Electrical Engineering Department stopped by for a visit. He gets back more often, now that his son is on the medical faculty at Tufts University.

A news release tells us that **David L. Lyon,** Ph.D.'72, along with others from M/A-Com Telecommunications, has formed Pacific Communications, Inc. Dave will serve as president. The firm will specialize in systems hardware and software for voice, data, and video networks in a number of mobile communications and terrestrial networking fields.

'Tis the week before Christmas as I write this article. I hope you all have memories of a Happy Holiday Season!—John A. Tucker, Special Assistant to the Department Head for VI-A & Lecturer, Room 38-473, M.I.T., Cambridge, MA 02139.

VII BIOLOGY

David Baltimore, '61, professor of biology at M.I.T. who is director of the Whitehead Institute for Biomedical Research, is now vice-chairman of the Board of Scientists' Institute for Public Information. SIPI's purpose is to bring together scientists and writers to improve the accuracy and quality of the news about science available in newspapers and other media.

Carolyn A. Bondy, S.M.'77, is a senior fellow in medicine at the National Institutes of Health, Bethesda. . . . From **Leo Cravitz,** D.P.H.'44, of Rochester, N.Y.: "Retired in 1985 from position as chief microbiologist at the Rochester General Hospital after 38 years of service. Enjoy retirement. Visit three married daughers and grandchildren in Boston, Cincinnati, and Norfolk; winter in Longwood, Fla., pursuing philatelic and other hobby interests. After 43 years of marriage, my wife Marcia and I are in reasonably good health and still very much in love."

VIII PHYSICS

After 35 years on the Columbia University faculty, **Cyril M. Harris,** Ph.D.'45, retired last July 1 to a chorus of accolades. He had been Charles Batchelor Professor of Electrical Engineering and professor of architecture, profiled by *Discover* magazine in 1982 as "the best acoustician in the world." In addition to the Gold Medal of the Acoustical Society of America, Harris won membership in the American Philosophical Society last year.

In *The Hunting of the Quark* (Simon and Schuster, 1987, $9.95 paper—$21.95 cloth), **Michael Reardon,** Ph.D.'68, not only chronicles the events stimulated by the discovery of the J particle by Professors Samuel Ting of M.I.T. and Burton Richter of Stanford in 1974. He also waxes philosophical about science and its progress: "In its relentless pursuit of objective truth," writes Reardon, "a scientific community resembles, if anything, a vast collective 'mind.' Of paramount importance to its vigorous growth is the free and rapid exchange of information among its many parts. . . . The truth scientists speak about is not some rigid, static entity 'out there.' It is a living, growing, evolving body of successful ideas they share with their colleagues."

From Glendale, Wisc., **Tsur Bernstein,** Ph.D.'71, writes that he has recently joined General Electric Medical Systems, Milwaukee, as manager of clinical applications in nuclear medicine. He was previously for eight years with Elscint, an Israeli medical imaging firm, with responsibilities in development (in Israel) and marketing (in Boston). . . . Three new academic appointments for alumni: **Fulvio Melia,** Ph.D.'85, now of Arlington Heights, Ill., is assistant professor of physics at Northwestern University; **Jerome C. Licini,** Ph.D.'87, has the same title at Lehigh; and **Matthew W. Deady,** Ph.D.'81, has moved from Mount Holyoke to Bard College, where he is now associate professor of physics.

Two major prizes in plasma physics were given to members of the M.I.T. community during the annual meeting of the American Physical Society's Division of Plasma Physics in San Diego late last year—the 1987 James Clerk Maxwell Prize to Professor **Bruno Coppi** and the 1987 Simon Ramo Award for outstanding doctoral thesis research to **Matthew J. Mayberry,** Ph.D.'86. Coppi was cited for "outstanding contributions to fundamental theory, experimental interpretation, and engineering design in fusion research," while Mayberry's award noted his work on tokamak physics.

From **Douglas C. Allan,** Ph.D.'82: "My wife Carol and I have started teaching ballroom dance classes in Corning, N.Y.; we are former members of M.I.T.'s Ballroom Dance Club."

Two deaths have been reported to the Alumni Association without further details: **Osmund T. Fundingsland,** S.M.'50, of Santa Barbara, Calif., on June 10, 1987, at the Adventist Hospital, Takoma Park, Md.; and **Otto J. Guentert,** Ph.D.'56, of Sudbury, Mass., on May 25, 1987.

X CHEMICAL ENGINEERING

Five members of the M.I.T. community were in the spotlight at the annual meeting of the American Institute of Chemical Engineers late last fall in New York:

☐ **James Wei,** Sc.D.'55, head of the department at M.I.T., was introduced as AIChE president, an office which he'll hold for calendar 1988.

☐ To **Gerald A. Lessells,** '50, of Clearwater, Fla., retired environmental services manager of J.M. Huber Corp., the 1987 F.J. Van Antwerpen Award for "untiring efforts to attract minorities and women into the chemical engineering profession and to broaden industrial career opportunities for them."

☐ AIChE's prestigious Founder's Award to two M.I.T. alumni—**John Happel,** S.M.'30, president

Bodman: Quality Is the Bottom Line

After 16 years in the top levels of the Boston financial community, Samuel Bodman, Sc.D.'65, is back with the technology he learned in chemical engineering at M.I.T. And it feels good, he says.

Bodman's move from the presidency of FMR Corp., the holding company for Fidelity funds, to Cabot Corp. made headlines and set tongues wagging a year ago. Little wonder: as president of FMR Corp., Bodman was number two in a business whose task was to manage $60 billion of investors' money and devise financial services that would bring in even more. At Cabot he became president of a conservative, principled company with worldwide sales of about $1.3 billion and heavy commitments in the slumping business of energy.

And it was just those qualities of a first-rate, principled company that drew Bodman to the new opportunities he believes Cabot Corp. offers, he told a standing-room-only audience at the Sloan School late last fall.

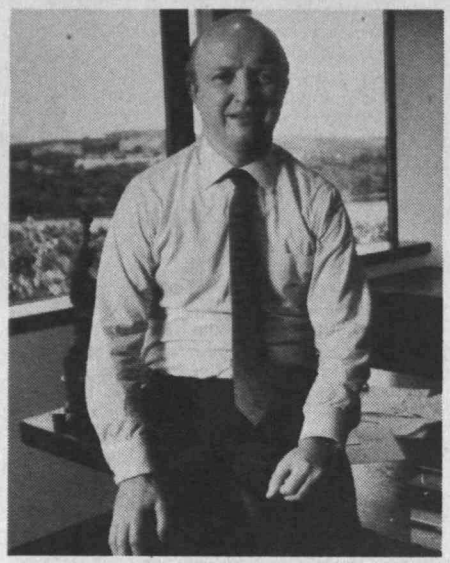
Cabot is "a company of quality," Bodman told his audience, "committed to high morals and service to customers, not to squeezing out the last dollar, determined to be a major positive force in the communities in which it is located."

And Bodman intends to keep it that way—a premium enterprise that will gradually grow into "one of the top companies in America," he told his audience.

Already, Bodman said, he has taken aim on that target by doing what any first-rate executive of a first-rate company has to do: making sure that the cost structure is "as low as is humanly possible. You have to know that in your heart—that's what it's all about," Bodman said.

"You don't get paid for going to the office; you get paid for making a difference," Bodman told his Sloan School audience—"for successfully analyzing problems and acting on the results of that analysis.

"You are uniquely placed in the Sloan School to learn how to do this, to create real value that lasts." □



After a spectacular career at Fidelity funds, Samuel Bodman, Sc.D.'65, finds a new challenge on his desk at Cabot Corp.: to maintain Cabot's high quality and integrity while building it into "one of the top companies in America," he told a Sloan School audience late last fall.

of Catalysis Research Corp., Palisades Park, N.J., and **Lee C. Eagleton,** S.M.'48, emeritus professor of chemical engineering at Pennsylvania State University; both were cited for "innovative industrial and educational contributions spanning more than 50 years."

□ The Materials Engineering and Sciences Division Award to **Stuart L. Cooper,** '63, chairman of the Chemical Engineering Department at the University of Wisconsin, Madison; he was cited for extensive contributions in biomaterials and other polymers.

Gregory Stephanopoulos, Joseph R. Mares Professor of Chemical Engineering at M.I.T., heads a new research consortium on the role of artificial intelligence in process engineering, and industrial memberships in the consortium are now available. Stephanopoulos believes that artificial intelligence may "change completely the way the chemical and biochemical processes are developed, designed, controlled, and operated," and the goal of the consortium is to bring M.I.T.'s strengths in chemical engineering and intelligent systems together with the interests of industry to explore these opportunities.

Lee P. McMaster, Sc.D.'69, vice-president and general manager of the Engineering Polymers Department at Amoco Performance Products, Inc., Danbury, Conn., has been appointed to a new advisory council to the College of Engineering at the University of Delaware, Newark. . . . **A. David Rossin,** S.M.'55, has been named assistant secretary for nuclear energy in the Department of Energy by President Reagan. In his new post Rossin manages an organization responsible for reactor development and demonstration programs, advanced reactor research, nuclear power systems for space and defense, waste technology activities, and uranium enrichment. Rossin was formerly director of the Nuclear Safety Analysis Center at the Electric Power Research Institute, Palo Alto, Calif.

In his third annual report as director of AIChE's Center for Chemical Process Safety, **Thomas W. Carmody,** '44, emphasizes four major projects: safe storage and handling of highly toxic materials, vapor release mitigation and vapor cloud dispersion models, technical management

PHOTO: BOSTON GLOBE

for chemical process safety, and quantitative risk assessment. The center, Carmody says, has grown into "a respected research and educational organization."

XI URBAN STUDIES AND PLANNING

John Bullard, M.C.P.'74, was reelected last November as mayor of New Bedford, Mass., with 65 percent of the vote. He also serves as the chairman of Massachusetts Governor Michael Dukakis' Committee on Gateway Cities, which addresses the problems immigrants face in the state.

As director of rapid schedules for the New York City Transit Authority, **Alex E. Friedlander,** Ph.D.'69, is responsible for all subway schedules. . . . Also in New York, **Daniel P. Kurtz,** M.C.P.'79, is vice-president for industrial development of the New York City Public Development Corp.

Mark Lawner, M.C.P.'66, is a partner at Woolpert Consultants, Dayton, Ohio, a 400-person firm (10 offices in 8 states) engaged in planning, economic studies, engineering, architecture, landscape architecture, environmental science, photogrammetry, computer graphics, and database management systems. . . . And **Michael L. Seltz,** M.C.P.'67, writes that Oldham and Seltz, Washington, D.C., of which he is a senior partner, has entered its fifth year with over 60 employees and a new office in Philadelphia.

Mauricio M. Gaston, M.C.P.'81, on the staff of the Center for Community Planning at the University of Massachusetts, Boston, passed away in September 1986, after a brief illness. Gaston, known as a community activist and active participant in the Rainbow Coalition, was a major figure in movements for tenants' rights. He was born in Cuba, moved to the United States in 1961, and at the time of his death was involved in a major project analyzing the relationship between disinvestment, reinvestment, and displacement in the Roxbury (Mass.) area.

XII EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES

John B. Southard, '60, has been promoted to the rank of full professor in the department at M.I.T., and **Marcia K. McNutt** has been promoted to associate professor. Southard is a geologist specializing in sedimentary processes, a leader in the M.I.T. Experimental Sedimentology Laboratory; McNutt, whose Ph.D. is from Scripps Institution of Oceanography, is working to relate details of volcanism and continental drift.

Two news items from Canada: Previously senior research geophysicist with Veritas Software, Ltd., **Robert R. Stewart,** Ph.D.'83, now holds a professorship in the Department of Geology and Geophysics at the University of Calgary, where he has been appointed to the chair in exploration geophysics. . . . **Seymour Shlien,** Sc.D.'72, writes from Ottawa, Canada: "I am doing research in the areas of signal processing, image processing, and pattern recognition for the Canadian Communications Research Centre. I am married and have two daughters, aged 3.5 years and 2 months, and still do international folkdancing—the most useful thing I learned during my years at M.I.T.!"

Norman F. Lacey, '42, who studied meteorology as a graduate student at M.I.T., writes, "I stepped down from my position as aviation meteorologist with the Central Florida Weather Service Unit under contract to the FAA in October 1987. Now volunteering at ION Weather in Morristown (Airport), N.J." . . . Another meteorology graduate, **Harold E. Taylor,** S.M.'62, reports from Stockton (Calif.) State College, where he teaches electronics, astronomy, and meteorology: "I have just returned from a year's sabbatical at Princeton's Center for Energy and Environmental Studies, where I worked on radon mitigation, energy in buildings, and security issues."

XIV ECONOMICS

In the last quarterly issue of *Leaders* magazine for 1987, consultant **William H. Gruber,** Ph.D.'65, answered the question, Are you really a CIO? No typo—Gruber means chief information officer, an emerging management position "to pull together the separate strands of technology and the business" in what Gruber calls "the electronic business era. . . . Now that a number of leading companies have begun implementing the CIO concept," writes Gruber, "competitive pressures should speed its acceptance."

The Reverend **Joseph R. Fahey,** S.J., Ph.D.'67, president of Boston College High School, has been re-elected a trustee of Fairfield University, Fairfield, Conn. Rev. Fahey, whose first term as a Fairfield trustee extended from 1971 to 1982, was formerly dean of faculties and academic vice-president of Boston College and earlier held similar posts at Holy Cross.

Steven Shavell, Ph.D.'73, of Harvard's Economics Department is the author of *Economic Analysis of Accident Law* (Harvard University Press, 1987). And **Halbert White,** Ph.D.'76, professor of economics at the University of California at San Diego, is co-author of *A Unified Theory of Estimation and Inference for Nonlinear Dynamic Models* (Basil Blackwell, Inc., 1988).

Family Financial Consultants, Inc., is a new financial counseling firm for single women, elderly, and couples needing help in managing their finances founded by **Michael R. Dohan,** Ph.D.'69, on Long Island; Dohan is also associate professor of economics and director of the Social Science Laboratory at Queens College of CUNY, Flushing, N.Y.

Steven P. Zell, Ph.D.'74, senior vice president—finance of AMC Entertainment, Inc., Kansas City, is now a director of TPI Enterprises, Inc., New York City.

From Stepney, Conn., **Charles J. Stokes,** '51, reports that he has been director of small business development at the University of Bridgeport since 1985; he was an endowed lecturer at Andrews University in that year and taught economics in India in 1987. "Publications galore as kids grow up, marry, produce grandsons, etc.," he writes. . . . **Arthur G. Ashbrook, Jr.,** Ph.D.'47, of Washington, D.C., describes himself as "semi-retired, engaged in contract work on a series of interesting economies: Mexico, Cuba, North Korea, Iran, Israel, and now Egypt."

XV MANAGEMENT

Having matured into a major Boston-area medium for discussing issues in finance and applied economics, the weekly seminar of the Sloan School's finance group is now acknowledging the financial support it has received for the last five years from Batterymarch Financial Management, Boston-based money management firm. The seminar draws participants from Boston and Harvard Universities and the Boston financial community; Professor Stewart C. Myers of the Sloan School is in charge.

Professor **Jay W. Forrester,** S.M.'45, of M.I.T. was twice honored in Shanghai last year during the 15th annual conference of the International System Dynamics Society. As founder of the field, described in the opening address of the conference as "preeminent among the many methodologies that are having impacts on man's view of and ability to solve problems in 20th-century society," Forrester was awarded an honorary professorship in the Shanghai Institute of Mechanical Engineering. And later he was honored with **Ching T. Yang,** '30, at a private ceremony dedicating a new Forrester-Yang System Dynamics Reading Room at Jiaotong University, Shanghai.

It was tough to leave Los Angeles, but **Joseph Combs,** S.M.'77, and his family finally accepted

the idea of living in the "snow belt" so that he could take a promotion to pricing manager for the National Marketing Division of Xerox in Rochester, N.Y. . . . Another departure from Los Angeles: after 18 years on the faculty at UCLA, **Ephraim R. McLean,** Ph.D.'70, has become the George E. Smith Eminent Scholar in Information Systems at the College of Business Administration, Georgia State University, Atlanta. . . . After 16 years with Lear Siegler, Inc., **Ronald C. Buehner,** S.M.'62, who lives in Rancho Palos Verdes, Calif., has joined the corporate office of Avery International Corp., Pasadena, as director of manufacturing and engineering. . . . **Raymond J. Epich,** S.M.'54, is vice-president of the Diebold Group, Inc., as its regional manager in Chicago.

International news: From Mexico City, **Manuel Campos,** S.M.'85, newly married to Elizabeth Fayrell, is off to a fast start: "Two years after leaving Sloan I have finished my first real estate development project of 46 apartments in Mexico City and am now starting a second one. Will be happy to say hello to any Sloans who visit Mexico; phone 557-07-38."

Senior Executives

Alan F. Dowling, '70, a member of Ernst and Whinney's Cleveland office staff, has been named a partner of the firm. Dowling is responsible for health care information systems counseling and management, and he serves on E&W's National Health Care Information Systems Committee. . . . **David W. McDonald,** '70, senior associate with the Technology Management Group of Pugh-Roberts Associates and affiliate professor of technology management at Washington University, St. Louis, served as the briefing leader of a one-day seminar held in Cambridge last November 18 and in New York City on December 1. The seminar, "Strategic Management of R&D: Linking Technical and Business Planning," was sponsored by Boston University's Metropolitan College. . . . **Andrew C. Knowles III,** '76, was promoted from vice-president to chairman of the CAD/CAM Workstations Group at Prime Computer, Inc., Natick, Mass. . . . **Keith A. Costa,** '77, has new responsibilities as senior vice-president and general manager of worldwide operations of Ciba Corning Diagnostics Corp., Medfield, Mass. Formerly, Costa served as president of Corning Medical and Corning Glass Works.

Walter J. Schmidt, Jr., '60, of Somerset, Colo., passed away on April 16, 1986; no further details are available.

XVII POLITICAL SCIENCE

A specialist in the politics of Asia and of the People's Republic of China, Professor Lucian W. Pye of M.I.T. is president for 1988 of the American Political Science Association. . . . McDonnell Douglas Astronautics Co., St. Louis, announced the appointment of **Edward R. (Randy) Jayne II,** Ph.D.'69, as vice-president of strategic program development; he's previously been with General Dynamics (staff vice-president—corporate planning, 1980-87) and the Office of Management and Budget (associate director for national security and international affairs, 1977-80).

Robert I. Rotberg, who has been professor of political science at M.I.T. since 1968, joined Tufts University in July as academic vice-president for arts, sciences, and technology. Rotberg is well known for studies of the politics and history of Africa and the Caribbean and for frequent contributions to major newspapers' op-ed pages on these subjects.

Dana G. Mead, Ph.D.'67, is currently senior vice-president for white papers business at International Paper Co., New York City. Mead formerly served as vice president and group executive. . . . **Thomas J. Biersteker,** Ph.D.'77, is the author of *Multinationals, the State, and Control of the Nigerian Economy,* published by Princeton University Press. The author evaluates the sources of Third World economic nationalism and assesses the significance of the changes that have taken place between the North and South since the early 1970s, using the case of Nigeria as an example. Biersteker is associate professor in the School of International Relations and director of the Center for International Studies at the University of Southern California.

XXII NUCLEAR ENGINEERING

To **Gordon L. Brownell,** Ph.D.'50 (VIII), professor of nuclear engineering at M.I.T., the Coolidge Award of the American Association of Physicists in Medicine, the highest award of AAPM for accomplishment in medical physics. Brownell's citation noted his contributions to positron imaging and absorbed fraction dosimetry and his excellence in teaching.

From Albuquerque, N.Mex., **David R. Boyle,** Ph.D.'80, writes, "Major activity of 1987 was creating a complete family from scratch. Anne and I adopted two children from Brazil, Edie (5) and Danny (4). These kids are absolutely beautiful and so smart that they learned to speak/understand English in a few months. Best thing I've ever done!"

William R. Corcoran, Ph.D.'71, has joined IT-Delian, a unit of International Technology Corp, where he is providing engineering and management consulting services at Pilgrim, Susquehanna, Comanche Peak, and South Texas Project nuclear stations. He serves on the M.I.T. Corporation's visiting committee to the department and lectures at M.I.T. each summer. . . . In New Britain, Conn., **Mark F. Samek,** S.M.'78, is engineering supervisor for instruments and controls at Northeast Utilities.

XXIV LINGUISTICS AND PHILOSOPHY

The Nature of Love: The Modern World (University of Chicago Press, 1987) completes a trilogy by Professor Irving Singer that is described as a philosophical history of the Western concept of love. In a prepublication review, Robert C. Colomon, author of *The Passions,* describes the series as "one of the major works of philosophy in our century . . . nothing less than monumental . . . a masterwork and a sourcebook that will be the standard work in the field." Anticipating broad appeal, the publisher is marketing the volume as a trade, or general-interest, book. Singer describes his reason for writing the trilogy: "to encourage people to find new, enriched, more creative, more imaginative ways of making sense for themselves out of human nature."

"Genocidal Science—Nazi and Nuclear" was the wrenching title chosen by Dr. Robert J. Lifton for his Arthur Miller Lecture at M.I.T. late last fall. Lifton is Distinguished Professor of Psychiatry and Psychology at the City University of New York and Mount Sinai Medical Center. It was the first in an annual lecture series in science and ethics established by Rose Miller in memory of her husband **Arthur J. Miller,** Ph.D.'39 (V), who had a long association with Union Carbide operations at Oak Ridge, Tenn.

Two books published by the M.I.T. Press late last year call attention to the work of Professor **Richard Cartwright,** head of the department at M.I.T. Edited by Professor **Judith J. Thomson** of M.I.T., *On Being and Saying* is a collection of essays dedicated to Cartwright; authors, in addition to Thomson, include Professor **George Boolos,** Ph.D.'66, of M.I.T., Professor **Harold Levin,** Ph.D.'76, of North Carolina State, and Professor **Scott Soames,** Ph.D.'76, of Princeton. *Philosophical Essays* is a companion volume of Cartwright's own writing. . . . Institute Professor **Morris Halle** of M.I.T. and Professor **Jean-Roger Vergnaud,** Ph.D.'74, of the University of Maryland are co-authors of *An Essay on Stress* (M.I.T. Press, 1988, $22.50); the authors present "a universal theory for the characterization of the stress patterns of words and phrases . . . in the languages of the world."

Barbara H. Partee, Ph.D.'65, is in the middle of her second year as head of the Linguistics Department at the University of Massachusetts in Amherst; she joined the department in 1972. Partee was 1986 president of the Linguistic Society of America.

TECHNOLOGY AND POLICY PROGRAM

Chris Barnett, S.M.'79, is with the Massachusetts Water Resources Authority as technical manager assistant to the chairman, Paul Levy, '72. . . . **David Cheney,** S.M.'83, is continuing his work with the Congressional Research Service at the Library of Congress, but will take a leave of absence to accept a one-year research fellowship at the Institute for Policy Science at Saitama University in Japan.

Carolyn Wong, S.M.'87, is working for Xerox in Sunnyvale, Calif., designing and developing desktop publishing software for Xerox workstations. . . . **Pascale Michaud,** S.M.'87, is working in Paris with the Transportation Ministry in the Direction des Transports Terrrestres. . . . **Seth Tuler,** S.M.'87, recipient of the 1986 Alumni Award for Excellence and Leadership in Technology and Policy, has joined the CENTED Research Group at Clark University doing risk analyses on nuclear power plants and radioactive waste deposits.

Elizabeth Mulcahy Chehayl, S.M.'79, has spent a successful two years implementing and managing medicare risk contracts for Blue Cross & Blue Shield of Ohio. She and her family will be relocating to the Chicago area in January.—Richard de Neufville, Chairman, Room 1-138, Cambridge, MA 02139.

George R. Vila, 1909-1987

George R. Vila, S.M.'33, retired chairman and president of Uniroyal, died on July 8 in New York City; he was 78.

Mr. Vila served as a member of the M.I.T. Corporation beginning in 1966 for a five-year term. He studied chemical engineering at M.I.T. following graduation from Wesleyan University, and he maintained retirement homes in New York and Sharon, Conn.

Richard F. Koch, 1895-1987

Professor Emeritus Richard F. Koch, who taught foreign languages at M.I.T. from 1930 until his retirement in 1961, died at his home in Bloomington, Ill., on October 13.

Koch was a native of Rochester, N.Y., and studied at the University of Rochester and Harvard before starting his teaching career at M.I.T.

August B. Kinzel, 1900-1987

August B. Kinzel, '21, for many years a leading figure in research at Union Carbide Corp., died at his home in La Jolla, Calif., on October 23; he was 87. He was a member of the M.I.T. Corporation from 1956 to 1961 and served on several of its visiting committees.

Kinzel took his degree in general engineering at M.I.T. after receiving a bachelor's degree from Columbia University, and he went on to earn a doctorate from the University of Nancy, France, in 1922. He joined Union Carbide's research subsidiary in 1926, becoming its chief metallurgist in 1931, vice-president in 1945, and president in 1948. Later he became Union Carbide's director of research and vice-president.

Kinzel is credited with the development of structural steel alloys and titanium manufacturing processes. He was the founding president of the National Academy of Engineering.

Deceased

The following deaths have been reported to the Alumni Association since the *Review*'s last deadline:

Jacob J. Bolotin, '19; August 23, 1986; Harrisburg, Penn.

Elbridge Wason, '20; October 19, 1987; Waban, Mass.

Charles A. Breed, '21; September 30, 1987; Laconia, N.H.

Winifred L. Foss, '21; August 3, 1987.

Augustus B. Kinzel, '21; October 23, 1987; La Jolla, Calif.

Hugh D. Chase, '23; May 16, 1987; Quincy, Mass.

David J. Flesh, '23; May 1, 1982; Jefferson, Tex.

Harold L. Townend, '23; June 3, 1987; Buffalo, N.Y.

Irving Weber, '24; November 23, 1986; Dallas, Tex.

Harrison Browning, '25; November 12, 1987; Tucson, Ariz.

Robert G. King, Jr., '25; October 4, 1987; Sarasota, Fla.

John L. Partin, '25; September 6, 1987; Laguna Hills, Calif.

Harvey C. Abbott, '26; October 16, 1987; York, Maine.

Charles D. Batchelder, '26; February 20, 1987; Winter Park, Fla.

Donald C. Chase, '26; November 5, 1987; Yarmouthport, Mass.

Frank N. Cramton, '26; September 21, 1987; Pocono Pines, Penn.

E(dward) Bird Kelly, '26; February 11, 1987; Nantucket Island, Mass.

Robert A. Williamson, '26; September 10, 1987; Fairview, Penn.

Henry G. Houghton, '27; October 21, 1987; Boston, Mass.

Eugene B. Lunden, '27; October 11, 1986; Davis, Calif.

Ralph F. Tefft, '28; July 9, 1987; Pittsburgh, Penn.

I(var) Theodore Malmstrom, '29; August 27, 1987; Honolulu, Hawaii.

Floyd W. Hall, '30; March 28, 1987; Bloomfield, N.J.

Schuyler N. Pyne, '30; June 13, 1987; Annapolis, Md.

Benjamin L. Smith, '30; October 19, 1986; New Canaan, Conn.

Jarolslaus Jerome Oleksiw, '31; October 4, 1987; Manomet, Mass.

Norman C. Thomas, '31; May 9, 1986; Newport News, Va.

Joseph E. Carbonell, Jr., '33; October 8, 1987; Greenville, Del.

John F. Duby, Jr., '33; March 24, 1987; Bellingham, Mass.

Prentiss L. Huddleston, '33; January 12, 1987; Tallahassee, Fla.

Edward C. Marshall, '33; May 15, 1986; Upper Montclair, N.J.

David L. Van Syckle, '33; October 23, 1987; Walnut Creek, Calif.

Charles A. Cogan, '34; May 10, 1987; Fort Meyers, Fla.

Clifford H. Hancock, '34; 1987; Newport News, Va.

Earl K. Murphy, '34; September 21, 1987; Huntington, N.Y.

George A. Zeller, '34; October 14, 1987; St. Louis, Mo.

Vito Castaldi, '35; September 3, 1987; Johnston, R.I.

G(eorge) Murlin Drury, '35; September 20, 1985; Portland, Ore.

Robert R. Spaulding, '35; September 29, 1987; Nokomis, Fla.

Clarence F. Funk, '36; May 14, 1986; Auburndale, Mass.

Lawrence W. Sharpe, '36; September 11, 1987; Lutz, Fla.

Philip D. Becker, '37; May 29, 1987; Southbury, Conn.

Florence J. Spring, '37; September 25, 1987; Big Horn, Wyo.

Ralph Werman, '38; August 1987; Needham, Mass.

Arnold L. Johnson, '39; October 15, 1987; Arcadia, Calif.

Addison V. Dishman, '40; July 25, 1987; Cocoa Beach, Fla.

C(harles) Cedric Ridgely-Nevitt, '40; May 6, 1986.

Eugene S. West, '40; April 25, 1986; Punta Gorda, Berlize Central America.

Gustav Juan J. Rizo Patron Remy, '42; April 23, 1981; Lima 27, Peru.

Donald B. Broughton, '43; December 2, 1984; Evanston, Ill.

Theodore R. Blakeslee III, '45; September 20, 1987; Raleigh, N.C.

Richard Mungen, '47; June 8, 1987; Tulsa, Ok.

Meyer S. Rosenthal, '47; September 17, 1987; West Orange, N.J.

Walter C. Benzing, '48; November 1987; Saratoga, Calif.

William I. Kushner, '48; June 15, 1986; New York, N.Y.

Holmes W. Taylor, '48; June 7, 1987; San Diego, Calif.

Philip H. Towle, '48; May 6, 1987; Chicago, Ill.

Kemp B. Reade, '49; July 7, 1987; Westport, Conn.

Osmund T. Fundingsland, '50; June 10, 1987; Santa Barbara, Calif.

Charles E. Heinrichs, '50; March 1987; Wayne, Penn.

David C. Prince, Jr., '51; October 16, 1987; Cincinnati, Ohio.

Richard W. Willard, '51; October 5, 1987; Winchester, Mass.

James A. Berkstresser, '52; February 8, 1987; Clearwater, Fla.

Donald E. Jarvis, '52; September 3, 1982; Dallas, Tex.

David A. Johnson, '52; September 8, 1987; Fayettville, N.Y.

William J. Burns, '53; February 4, 1987; Rockford, Ill.

Torsti Kulmala, '54; 1986; Carlisle, Mass.

James H. Whitley, '54; October 14, 1987; Harrisburg, Penn.

A(lan) Jay Goldstein, '55; October 23, 1986; Livingston, N.J.

Otto J. Guentert, '56; May 23, 1987; Sudbury, Mass.

Elizabeth M. Slayter, '60; July 11, 1987; Lincoln Center, Mass.

Alfred C. Molla, Jr., '61; August 9, 1985; Satellite Beach, Fla.

Bertrand B. Bishop, '62; October 5, 1987; Accord, N.Y.

Kanu R. Gandhi, '63; 1987; Sewagram Via Wardha, India.

Harold Payson, Jr., '63; September 1987; Bristol, R.I.

Edward S. Shaw, '65; August 10, 1987; Arlington, Mass.

Ahmes M. Khalifa, '68; July 25, 1987; London SW1 8RX, England.

James J. Zilli, '71; October 26, 1987; Poughquag, N.Y.

Erland van Lidth de Jeude, '76; September 23, 1987; New York, N.Y.

Samuel O. Amponsah, '79; October 16, 1987; Mattapan, Mass.

Thomas F. Trobaugh, '79; October 22, 1987; Somerville, Mass.

Melanie H. Amponsah, '86; October 16, 1987; Mattapan, Mass.

ALLAN J. GOTTLIEB, '67

What Happened 'Ere I Saw You Last?

Let me begin with several contributions from readers.

Albert Mullin notes that James Joyce anticipated important parts of modern physics—more precisely the vocabulary of modern physics. For example, "gauge symmetry" (. . . "gauging the symmetry . . ." uttered by Bloom in *Ulysses*) and "quarks" ("Three quarks for Muster Mark!" in *Finnegans Wake*). Mullin adds that less well known is Joyce's mathematical puzzle appearing in *Ulysses*, in which the hero Bloom, a forerunner of modern graph theorists, ponders the problem of crossing Dublin without passing a pub, only to abandon the attempt as impossible.

A local newspaper noted that the New Bedford (Mass.) Great Books Discussion Group founded by our Mary Lindenberg *40* years ago is one of the oldest such groups in the country. Indeed, that is twice the age of "Puzzle Corner."

Matthew Fountain has written about Captain Waterman, who founded the city of Fairfield, Calif.:
After setting several speed records in clipper ships under his command, Waterman had to leave the sea due to the notoriety he gained as a hard master. He had earlier bought a one-third interest in 30 square miles of land northeast of San Francisco for $16,666. I'll bet it's worth a *lot* more now.

Readers interested in handmade wooden jigsaw-puzzles, tangrams, and casse tete should write to Ateliers de la Petite Pree, Pierre Jouan, La Godiniere, 49150 Cheviere-le-Rouge, France.

Stephen Cheng, a colleague of mine at Baker House (and especially the Baker House ping-pong tables), has just completed a book entitled *MOS Digital Electronics*. Finally, Neil Cohen notes that after 39 years of bachelorhood he married Lea Linsk. Best wishes to you both.

SEND PROBLEMS, SOLUTIONS, AND COMMENTS TO ALLAN J. GOTTLIEB, '67, THE COURANT INSTITUTE, NEW YORK UNIVERSITY, 251 MERCER ST., NEW YORK, N.Y. 10012.

Problems

F/M 1. Our first challenge is a computer-related problem from Jim Landau, which essentially asks for a nonrecursive version of Oren Cheyette's solution to **1986 N/D 2**. Landau writes:
Define an ordering of the $n!$ permutations of n objects by considering the objects as the first n letters of the alphabet and arranging the $n!$ permutations in alphabetical order. For n = 3 this gives

1. A B C	4. B C A
2. A C B	5. C A B
3. B A C	6. C B A

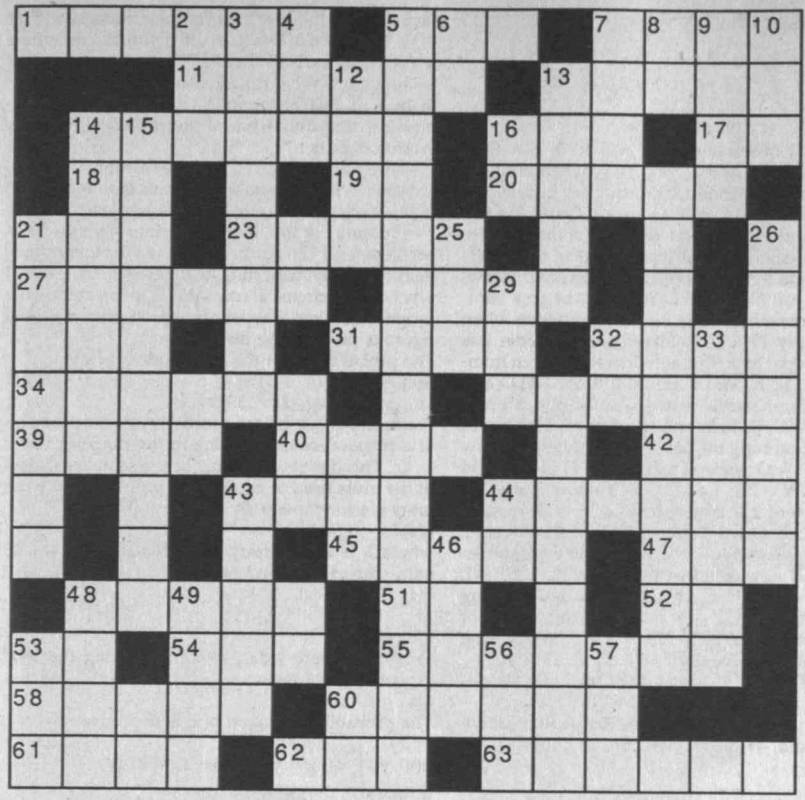
The mth permutation is now defined as the permutation that is number m in alphabetical order. Devise a nonrecursive algorithm and/or write a program which will find the mth permutation of n objects. By nonrecursive I mean that the algorithm can find the mth permutation without knowing (or computing) the $(m-1)$th or any other permutation.

F/M 2. Frank Rubin has positive integers x and y and now needs to find positive integers a, b, c, and z satisfying $a^x + b^y = c^z$.

F/M 3. Nob Yoshigahara wants you to find the smallest integer A such that the first ten digits of the square root of A are distinct.

F/M 4. Here is a cute problem originally contributed by Solomon Golomb to the *Johns Hopkins Magazine*:
Form palindromes of the type "—— was I ere I saw ——," where the *last* word of the sentence is a place name, and where the cleverness of the composition depends on to whom you attribute it. The classic is "able was i ere i saw elba," attributed to Napoleon.

F/M 5. Our last regular problem is a crossword puzzle by Dave Wagger that first appeared in the *Graduate Student News*, a publication of the M.I.T. Graduate Student Council. No solution was supplied, and the editor suspects that no complete solution is possible. Can our readers best the best that graduate students have to offer?



ACROSS

1. Better than brand A
5. This place
7. —— and crafts
11. 5A's expense
14. What a naive grad can get if not too careful
16. Winter hazard
17. Not down
18. Medial suffix
19. Bismark's state
20. Research tool
22. A level (abbr.)
23. Famous campus lunch vendor
27. Survey again
28. Chicken shop?
30. M——A (jock institution)
31. "R" on a schedule
32. Nephew "Fijian"
34. Common grad affliction
39. Common transportation
40. 43560 sq ft
42. ——ence
43. It takes forever here
44. Across the river
45. First performance
47. Anglo-Saxon god of peace
48. 100% person, if you want an apartment
51. Opposite of NW
52. Outside diameter
53. Not DC
54. Gazelle
55. Graduate dean
58. Possessive
60. Associate graduate dean
61. Course VI
62. See 44 across
63. Something to beat

DOWN

2. Type of register
3. Current M.I.T. experiment
4. Yuppie car
5. Popular watering hole
6. Form of "to be"
7. M.I.T. street
8 Week before classes
9. Given to prospective students
10. 273k, 1 atm
12. Await a decision
13. What to do with extra tickets
14. Editor
15. Very hard to find
16. Springfield is the capital
21. Wham-o
25. Old French coin
26. Student problem (nonhealth)
29. Boundary (comb. form)
32. Against (abbr.)
33. You might not want this from the commons
43. Some departments require this
44. Can cross-register here
46. Go to 50 for this
48. Another grad complaint
49. A computer system's protection
50. Some grads are/have this
53. What one did at 23A
56. Found in E23
57. Latest graduate foe
60. "Et ——, Brutus"

Speed Department

SD 1. Timothy Maloney sends us a "speed" problem based on a real-life incident; but it is not quite so simple as that: beware, trivia knowledge is required:

Last summer my cousin Jeff and I discovered that we went to the same summer camp at the same age, but at different times. "That was a third of my life ago," said Jeff. I replied, "That was two thirds of my life ago." I went to this camp when we all first heard Neil Sedaka sing "Breaking Up is Hard to Do." If it is now 1986, how old is Jeff?

SD 2. Howard Sard wants us to construct a bridge deal such that North-South can make 7NT against best defense holding the minimum number of high-card points.

Solutions

OCT 1. A bridge player holding the following hand took five tricks in his own hand. Nobody made any illegal plays. What was the deal and how did the play go?

♠ 4 3 2
♥ 4 3 2
♦ 4 3 2
♣ 5 4 3 2

Charles Blair found a solution in which *six* tricks are taken. As a fringe benefit I now have have a set of T_EX subroutines for printing bridge hands. These are available upon request. Blair writes:

I enjoyed the problem and thought you might like to see a deal in which a hand containing no cards higher than 5 (see West, below) wins *six* tricks:

	♠ A K Q J 10 ♥ A K Q J 10 ♦ 5 ♣ K 9	
♠ 4 3 2 ♥ 4 3 2 ♦ 4 3 2 ♣ 5 4 3 2		♠ — ♥ — ♦ A K Q J 10 9 8 7 6 ♣ A 8 7 6
	♠ 9 8 7 6 5 ♥ 9 8 7 6 5 ♦ — ♣ Q J 10	

With clubs trump, West leads a diamond, and East plays four rounds while North and South throw hearts. West trumps the fourth round (first trick he wins) and leads a trump to East. West trumps the fifth round and leads a spade trumped by East. West trumps the sixth round of diamonds as North throws his last heart. Now West is just able to cash three hearts without anybody trumping. Maybe there is even a way to win seven tricks, although I doubt it.

Also solved by Matthew Fountain, Stephen Callaghen, Richard Hess, Charlie Larson, Gerald Roskes and Stefan Ralescu, Steven Feldman, Robert Bart, Gerald Lippey, and the proposer, Lawrence Kells.

OCT 2. Show that for k, r, and positive integers the expression

$$\sum_{k=1}^{r-1} \frac{r!n^k}{k!(r-k)!}$$

is always even—i.e., an integral multiple of 2.

Linda Kalver begins by noting that

$$(1+n)^r = \sum_{k=0}^{r} \frac{r!n^k}{k!(r-k)!}.$$

Hence

$$\sum_{k=1}^{r-1} \frac{r!n^k}{k!(r-k)!} = (1+n)^r - (n^r+1).$$

Since any integer has the same parity (odd or even) when raised to any positive power, the two terms on the right hand side have the same parity and hence their difference is even, as required.

Also solved by James Landau, Scott Berkenblit, John Chandler, Winslow Hartford, Chip Whiting, Matthew Fountain, Harry Zaremba, Richard Hess, Steven Feldman, Robert Bart, and the proposer, Hy Tran.

OCT 3. A "numble" is an arithmetical problem in which digits have been replaced by capital letters; there are two messages, one which can be read right away and a second one in the digit cipher. The problem is to solve for the digits. Each capital letter in the arithmetical problem stands for just one digit 0 to 9. A digit may be represented by more than one letter. The second message, expressed in numerical digits, is to be translated (using the same key) into letters so that it may be read; but the spelling may use puns or deliberate (but evident) misspellings, or may be otherwise irregular, to discourage cryptanalytic methods of deciphering.

```
      T H E
  x   W O L F
  -----------
      K T L O
    E W T F
  S W E W
H H W L
-------------
W L I W O O O
```

Many readers questioned the meaning of "Each . . . letter . . . stands for just one digit . . . [but] a digit may be represented by more than one letter." Frankly, I just do not see the problem. Were there 13 different letters in the problem (remember, the instructions were describing a class of problems), one would always have a digit represented by more than one letter even if each letter stands for just one digit. Perhaps even simpler is to consider a problem with five letters all standing for zero. Certainly the wording about the second message *was* confusing; however, Matthew Fountain figured out what should have been said (possibly the most challenging part of the problem) and writes:
The arithmetic problem is

```
      9 7 3
  x   8 6 4 2
  -----------
      1 9 4 6
    3 8 9 2
  5 8 3 8
7 7 8 4
-------------
8 4 0 8 6 6 6
```

and the message is

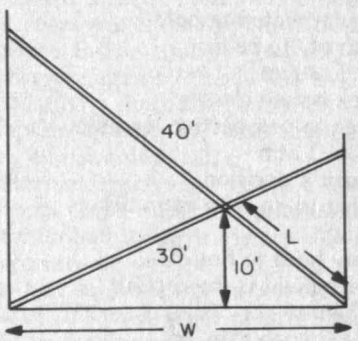
```
0 1 2 3 4 5 6 7 8 9
I K F E L S O H W T
```

or IKE FELL, SO WAIT.

I began by observing that E × F = O, E × O = W, E × W = L, and E × L = F, when only the last digit of each product is considered. This shows that O is not an odd digit, as an odd O would force E, W, L, and F to be odd also. But none of these five letters equals 1, and the set of five odd digits must include 1. Therefore O is even, and consequently so are W, L, and F. Six letters begin a number and three others yield four-digit products when they multiply THE. This leaves only the letter I as the letter equal to 0. This accounts for all even numbers. T, H, E, K, and S are odd. Since KTLO and the other three partial products must not exceed 8 × 975 = 7800, K, E, S, and H are not 9. This leaves T to be 9. Scanning the columns of additions, I saw that L + F = O without a carry, for O is even and T + T + W = O, i.e., 9 + 9 +(even digit)= O plus a carry of 2. I then saw W − 2 = O, making W larger than O which in turn is equal to the sum of L and F. W = 8, O = 6, and L and F are the set of 2 and 4. I now could write THE × W = HHWL = 9HE × 8 = HH8L. H, being odd, is 7. Making this substitution, 97E × 8 = 778L. E cannot be 1 or 5; therefore it must be 3. 973 × 8 = 7 784, making L = 4, and consequently F = 2. From THE × F = KTLO = 973 × 2, it is seen that K = 1. This leaves S, the last remaining digit, to be 5.

Also solved by Richard Hess, Robert Bart, Frederick Furland, Winslow Hartford, and John Chandler.

OCT 4. Given an alley of width W. Two ladders of length 40 ft. and 30 ft. are laid against opposite walls. They intersect 10 ft. above the ground. Find W and L, the width and one of the lengths of intersection.



The following solution is from Edward Dawson:
Given: AD = 40, BC = 30, and EF = 10.
From similar triangles, CF/EF = CB/BD = $W/\sqrt{30^2 - W^2}$. Therefore
$CF = 10W/\sqrt{30^2 - W^2}$.
In like manner, $DF = 10W/\sqrt{40^2 - W^2}$, and
$CF + DF = W = 10W/\sqrt{30^2 - W^2} + 10W/\sqrt{40^2 - W^2}$. Let $x = \sqrt{9 - (W/10)^2}$; then $[x/(x - 1)]^2 - x^2 = 7$ and x = 1.49094.
Hence $W = \sqrt{9 - x^2} = 26.033$.
$L = ED = (EF/AC)AD = (10)(40)/\sqrt{40^2 - W^2} = 400/\sqrt{922.283} = 13.171$.

Also solved by John Chandler, Sidney Williams, Harry Garber, Mary Lindenberg (who notes that my feeling that the problem might have appeared here ten or fifteen years ago was too conservative; it appeared in 1970), Kelly Woods, Winslow Hartford, Richard Marlowe, Chip Whiting, Matthew Fountain, Harry Zaremba, Ken Rosato, Williams Evans, Richard Marlowe, Frederick Furland, Robert Bart, Steve Feldman, Edward Martin, Richard Hess, and the proposers, Joseph Molitoris and George Butwin.

OCT 5. Suppose you take a table of physical constants expressed in scientific notation (e.g., the speed of light is 2.998 × 10^8 m/s) and construct a histogram of the first digits of their mantissas (e.g., 2, for the speed of light). In other words, count how many times each of the digits 1 to 9 occurs as the leading digit. What functions *a priori* do you expect to best fit this histogram? That is, for a random physical constant, what is the probability that its leading digit is n?

Many readers realized that the distribution is logarithmic, with some noting that this is an outgrowth of the "independence of scale" (see below). Richard Hess points out that Martin Gardner discussed this problem, and Leo Sartori confirmed the logarithmic distribution by inspecting an up-to-date table of 133 physical and chemical constants. I am reprinting the proposer's (Oren Cheyette) solution since it gives a rigorous proof of the distribution:
The probability that the leading digit is n is
$p(n) = \log_{10}[(n + 1)/n]$.
i.e., $p(1) = \log_{10} 2 \approx .30$, etc.
Proof: Let $q(x)dx$ be the probability of the mantissa of a physical constant being in the range of x to $x + dx$. This distribution must be the same regardless of the units used to express the numbers (since the units are fundamentally arbitrary). Hence
$q(x)dx = q(\lambda x)d\lambda x$
where λ is an arbitrary scale factor. Differentiate with respect to λ, and set $\lambda = 1$ to obtain
$q(x) = -xq'(x)$
or
$q'/q = -1/x$.
Integrating both sides, and normalizing the total probability to 1 gives
$q(x) = 1/(x\ln 10)$.
The probability function $p(n)$ is then given by:

$$p(n) = \int_n^{n+1} q(x)dx = \ln[(n + 1)/n]/\ln 10$$

$= \log_{10}[(n + 1)/n]$.

Also solved by Harry Zaremba, Matthew Fountain, Winslow Hartford, John Chandler, Scott Berkenblit, Gerald Lippey, and Alain Hanover.

Better Late Than Never

1987 F/M 3. Frank Rubin argues (rather convincingly, I believe) that "the answer 'anything' [you were to find the eleventh terms in certain sequences—ed.] is a fine surprise ending, sort of like finding out the murderer was Perry Mason himself."

M/J 1. Jim Landau notes that he did not solve the problem and therefore Winslow Hartford was the *only* one to solve it, a very rare occurrence.

A/S 1. William Hart and Lawrence Kalman have responded.

A/S 2, 3, 4. Naomi Markovitz has responded.

A/S 5. George Parks has responded.

Proposers' Solutions to Speed Problems

SD 1. Jeff is 18. We each went to camp at age 12, and Neil Sedaka first sang his song in 1962. (Without the trivia question, we know only that I am now twice as old as Jeff.)

SD 2. Eleven points suffices.

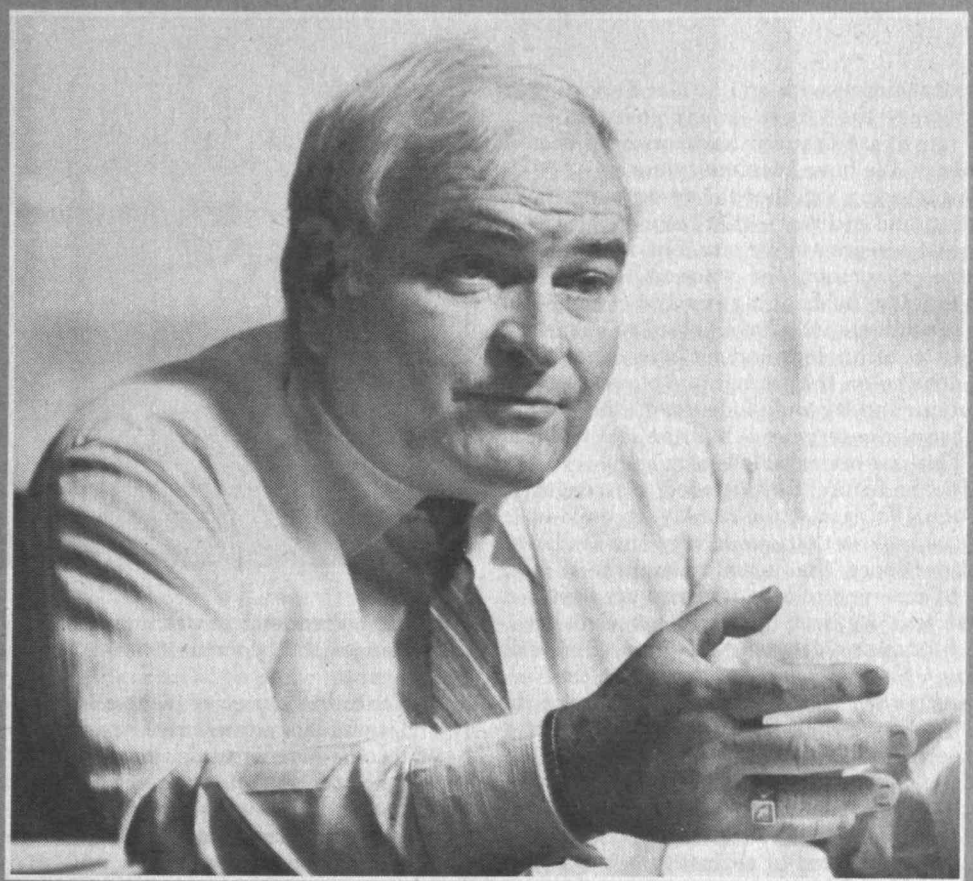
North
♠ —
♥ —
♦ 9 8 7 6 5 4
♣ 8 7 6 5 4 3 2

West
♠ K
♥ K Q J 10 9 8 7 6 5 4 3
♦ —
♣ —

East
♠ —
♥ —
♦ A K Q J 10 3 2
♣ A K Q J 10 9

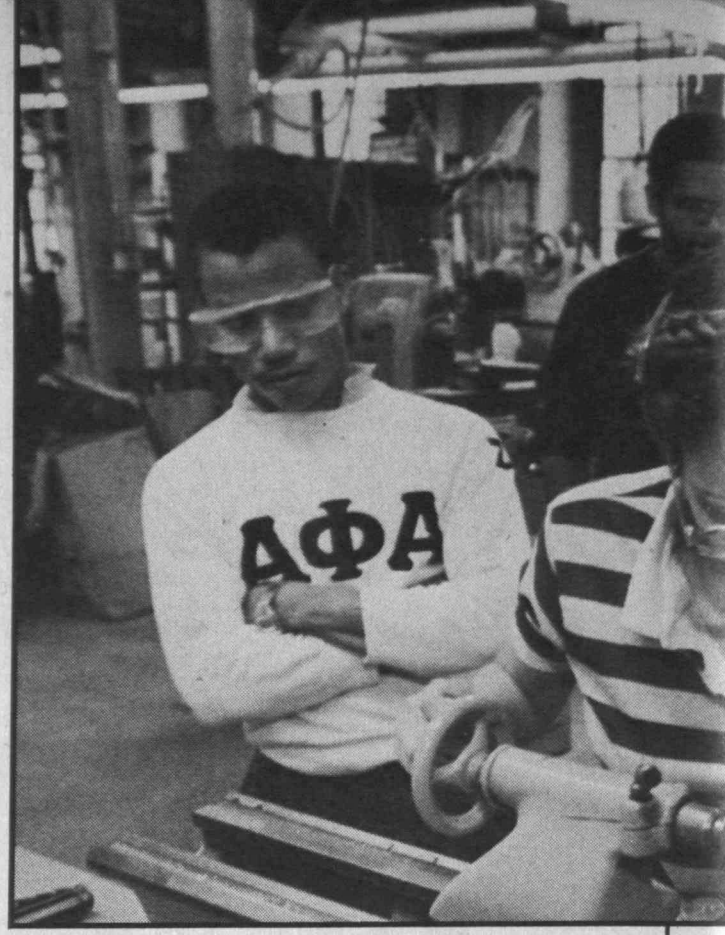
South
♠ A Q J 10 9 8 7 6 5 4 3 2
♥ A
♦ —
♣ —

MASSACHUSETTS INSTITUTE OF TECHNOLOGY



REPORT OF THE PRESIDENT

FOR THE ACADEMIC YEAR 1986-87



MIT is an institution with an unusual dedication and commitment to the future. At any point in our history, it is fair to say that our horizons have been in the next century. We have been enormously successful in gathering together the resources—the people, funding, and facilities—that have enabled us to create a great research university, one with the confidence, the enthusiasm, the concerns, and the ability to invent new fields of inquiry and educate generations of students who have helped to shape the course of science, technology,and society.

We have done so on the strength of our vision, on the talents of our faculty and students, on the confidence that our enterprise is built on and will lead to the best. This is a remarkable legacy and foundation for the future. But we need to strengthen that foundation. We need, quite frankly, to build up our own capital base so that our faculty and students have the independence, the flexibility, and the opportunity to act—and to be—at their very best.

In the past year, we have mobilized ourselves for the greatest fundraising drive in MIT history. We call it the Campaign for the Future. In describing the Campaign in this way, we are speaking not just of the future of MIT. We are speaking about the future of a world that the people of MIT will help create.

Our challenge, as we chart our future course, is to set our priorities and forge educational and research programs that will lead to a better world. This Campaign rises directly out of an Institute-wide effort to define our goals and focus even more sharply an educational offering that is already, we are convinced, one of the world's finest. Over the last several years, we have examined the effectiveness of our educational and research programs. Academic departments throughout the university have prepared five-year plans, with special emphasis on fields offering greatest promise for intellectual breakthroughs and social influence. Faculty and students have worked together in a major examination of the undergraduate educational program.

This kind of activity is not new to us. MIT has never been content with a static definition of its role. This was true when William Barton Rogers established a new kind of school in the 1860s and when Karl Taylor Compton led in the rebuilding of MIT as a scientific university in the 1930s and 1940s. Throughout our history, MIT has been determined to lead, not only in raising the standards of the engineering and architectural professions, but also in rebuilding the social sciences and pressing the search for scientific knowledge and the exploration of its implications for humanity.

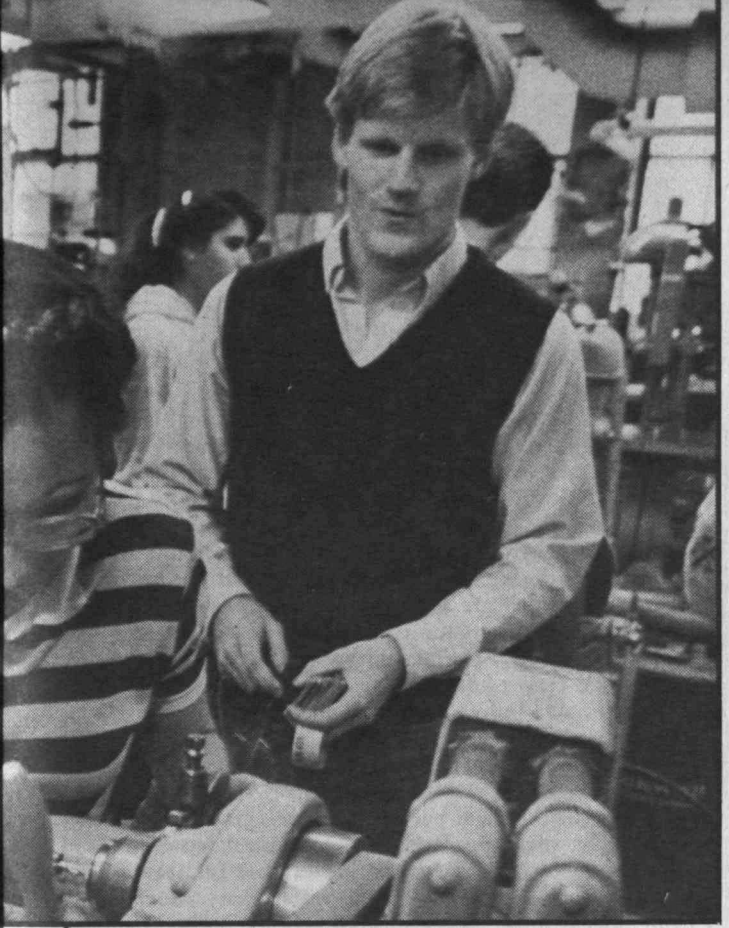
This leadership has been called on repeatedly in the service of the nation and the world. At no time has this leadership been as needed, as relevant, as it is now—when we face some of the most dramatic medical, economic, environmental, and political challenges and opportunities the world has ever known.

Central to our effectiveness is the excellence of our undergraduate education. The young men and women who come here as students, after all, are the future. Our hope for the future rests just as surely with them—and with what they learn here—as it does with the discoveries and advances in knowledge that our faculty produce.

As we consider the challenges ahead, we ask, "What sets MIT apart?" The answer is that MIT has become a science-based university that places special emphasis on undergraduate education. And it is a university in which faculty and students are partners in the academic enterprise. These partnerships have created an atmosphere, a dynamic, a way of working, that stimulates innovation and the evolution of ideas. There is a sense of fire and bite and excitement that comes from laboring with, and playing with, ideas. At MIT, learning is something that goes on all the time—in corridors, in classrooms, in research labs, in dining halls, on the playing fields. It does not go just one way, from teacher to student. We are all learners here—generations of learners in partnership, tugging at the edges of the known universe, speeding the process of innovation through new ways of seeing and understanding the world, through new ideas and new applications.

In such an environment, the goals of our Campaign are not the end, but the means to the end. The Campaign will distill and intensify the spirit and the culture that pervade life at MIT. It is an extraordinary culture, dominated by a sense of challenge and opportunity. Marking every faculty member or student who is, or has been, a part of this place is a sense of the possible. There is the expectation that

PHOTO: RANDALL WARNIERS



you can do your best, that you will do your best, because you are challenged here to reach higher and further, to think more rigorously, to probe more deeply, to question more critically—not only to solve the problems but to shape the issues.

To build on the excellence of this unique environment is our touchstone, and it is the fundamental goal of our Campaign for the Future. This Campaign, like this university, leads from strength. We go forward with the confidence that comes from constant renewal.

A Time of Renewal in Research and Education

Why does this seem such an auspicious time to take a searching look at our educational and research programs? The answer lies partly in the evolving nature of knowledge—of the changing contours of the intellectual map, so to speak—and in the nature of the issues and problems that our graduates will encounter once they leave here.

This report will discuss some of the reasons and some of the ways that MIT is addressing the challenges facing research and education as we stand on the threshold of the next century.

From the beginning, MIT's faculty have known that science and technology live in society, not apart from it. Indeed, the continuing conversation between technical capabilities and human needs may well be the essence of MIT. This idea was at the heart of Rogers's founding concept of a new kind of university, and it has informed the development of the Institute for more than a century. It is the impetus for the current spirit of renewal in our research and educational programs.

There is little argument that science and technology have made major contributions to human welfare, particularly in the United States. Although opportunities are not yet available to all, ours is a wealthy country, rich in natural resources and people and education, and rich in the technical boldness and entrepreneurial skill that are essential for us to make the most of what we have. Americans have, in fact, set an example to the world by fostering research and development for continual advances in productive efficiency and material well-being. The people of MIT—its faculty and graduates—have been central to this technical progress and its attendant advances in economic security, health, and social well-being.

And yet, over the past quarter century, there have been growing concerns over the present and future place of science and technology in our society. And there are concerns about the ways new knowledge can serve a world still beset with hunger and strife. These concerns have been expressed in many ways. There has been skepticism over whether we can use technological advances in a socially and environmentally responsible manner. There has been an alarming decline in scientific literacy in this country. There has been doubt that this country still has the edge in rapidly and successfully translating technological advances into economic advantage.

These concerns underline the fact that the development of technology has become much more complex and proceeds at a much greater pace than in the past. The definition of problems, the nature of the inquiry itself, requires partnership and collaboration among individuals from several fields from the very beginning. When it comes to such areas as biotechnology, the development of new materials, or the remaking of the industrial economy, it is no longer enough for the engineer to look to the scientist for a menu of new ideas that may hold interesting potential applications. It is no longer enough, if it ever was, for the university to stand alone in defining and working on such major problems.

There is a need for a new paradigm: a synthesis that requires understanding and cooperation among people from various disciplines and institutions and points of view. At the technical level, this interdisciplinary imperative signals a blurring of the historical distinctions between science and engineering. Beyond that, there is a need to reconcile technical considerations with considerations of the ecnomic, politcal, social, and environmental impact in a fundamental way. To do this successfully, we in the academy must look to and learn from our colleagues in business and industry, in other social and cultural institutions, and in government as well.

This new paradigm holds implications for both the research and the teaching programs at MIT. It is a model that fits this place well, given our long tradition of identifying new fields and creating new working

Initiatives are being shaped in many domains, in areas as diverse as materials, manufacturing, the brain sciences, and housing.

partnerships across older intellectual and institutonal boundaries. Indeed, MIT may well be better suited to pursue this model than any university in this country.

Implications for Research

Over the past several years, MIT faculty have been engaged in intensive planning of long-range research agenda. Once of the most exciting aspects of the Campaign is the development of a number of new research initiatives that will be made possible by the availability of additional resources. These initiatives are being shaped in many domains, in areas as diverse as materials, manufacturing, the brain sciences, and housing.

For example, in the broad area of materials, almost everything we use—from automobiles to electricity to pharmaceuticals to medical prosthetics—involves the intricate cooperation of many types of materials. Understanding the processing and function of these materials draws on fundamental knowledge of physics, chemistry, and biology, and of manufacturing and process engineering. Moreover, it requires a new level of cooperation between faculty and students in many fields, as in our new polymer science and technology program, where faculty in the Schools of Science and Engineering are developing a new interdepartmental graduate education and research program that builds on—but goes beyond—our traditional strengths in polymer research activities. What they learn and what they create will affect our communications, our transportation, our comfort, and our health.

In another area, manufacturing, it is widely recognized that US industry must undergo rapid changes in the next few years if this country is to remain economically viable. Here again, new paradigms are needed. Faculty in the Schools of Engineering and Management are committed to developing a major educational program in which manufacturing leaders will acquire both managerial and technical expertise, and the ability to operate manufacturing companies as integrated systems that can respond quickly to changes in the economic, political, social, and technological environment. We have taken the first steps with our management of technology program, but are seeking partnerships with our colleagues in industry to pursue the more ambitious agenda of rethinking the entire manufacturing process—from planning and product design through production, management, and marketing.

In activities that involve the Schools of Science, Architecture and Planning, Humanities and Social Science, Engineering, and Whitaker College, faculty are seeking new ways to understand the human mind. Studies of nerve function, the nature of sensation and perception, and the physical basis of consciousness are being combined with new insights from artificial intelligence to understand the "programs" that the brain runs, and the kinds of computation required to run them. Other pioneering areas include the study of language acquisition by children and the possibility of a genetically determined language faculty of the mind, studies of the delicate and sophisticated chemical balances in the brain, and construction of sophisticated robotic arms and hands in order to understand better how the brain controls motion.

And, finally, individuals from planning, architecture, building construction, economics, government, industry, social planning, and other backgrounds of expertise are being drawn together to tackle one of the most perplexing problems America faces today—housing. Recent MIT research, for example, predicts that the number of poor families without adequate and affordable housing will grow from a present 3.5 million to more than 7 million by the year 2003 as the result of economic and policy changes set in motion by tax reform and deregulation, among other factors. Beyond that, affordable housing is increasingly beyond the reach of many middle-income Americans. The MIT Housing Policy Project, conducted through the Department of Urban Studies and Planning and the Center for Real Estate Development, is exploring such fundamental issues as the role of government programs and regulations in housing production and availability, the demographics of housing, new construction technologies, and the homeless and housing. The goal is nothing less than the formation of new housing policies for the nation.

Many of the initiatives being planned in these and numerous other fields are built on MIT's tradition of interdisciplinary collaboration. They reflect the emerging model of even greater synthesis and integration among various fields. Their roots are in the activities of faculty members across the Institute who have seen the need to address some old problems in new ways, or who have identified wholly new research issues requiring new approaches.

Clearly, in a research environment as diverse and vibrant as MIT's, the themes of materials, manufacturing, housing policy, and the human mind do not begin to embrace the range of research agenda that are taking shape. And these agenda themselves do not cover the entire challenge of scholarship and research at MIT. As we move forward in new directions, we must preserve the quality and integrity of our core strengths in engineering and science, in the humanities and social sciences. Basic disciplinary research and scholarship have been and will continue to be one of the underlying strengths of MIT.

Nonetheless, some of the new directions being pursued here by faculty, students, and research staff are indications of an exciting future for this institution, and of significant and long-term

PHOTO: BRAD HERZOG

Professor D. Eleanor Westney (Sloan School of Management): international business management.

contributions to the larger society. Both content and boundaries of fields are being redefined. Perhaps most importantly, these areas of interest hold as much promise for our educational programs as they do for our research agenda: they draw on that quintessential MIT spirit of partnership between faculty and students of all ages.

That spirit was summed up by one of our senior faculty, who recently said:

"It's an incredibly exciting time to be at MIT, because there is so much going on here that is at the cutting edge. The sense of potential and opportunity is all-pervasive, with faculty and students sharing in the process of discovery. In fact, several of my most exciting research projects originated in an idea that a student brought to me and that we developed together. Our goal in educating students is not to turn out people who will reproduce the past, but people who will break new ground, make new discoveries, and set the pace for the future."

This spirit and these few examples illustrate the enormous potential that research at MIT has for making contributions of major significance to our own lives, and generally to our economy and society.

Implications for Education

It is somewhat arbitrary, in discussing education at MIT, to separate that discussion from consideration of the research agenda. Students at every level, after all, are partners in the research enterprise, and the research and scholarly activities of the faculty find their way quickly into the curriculum. Indeed, it is fair to say that everything that goes on here—in the classroom and in the laboratory—is education That is what our faculty and students are doing: learning.

Nonetheless, there are aspects of education here, particularly at the undergraduate level, that stem from a primary concern for educating the whole person, not solely the future professional. The independent, questoning, problem-solving habits of mind that are solidified and burnished by an MIT education, require engagement with a broad, complex, and changing set of facts and ideas. The young men and women who come to us leave here as citizens of the world, and the education we offer should enable them to move in that world as creative, sovereign human beings. If MIT is to achieve its full potential in this regard, we must continually review and redefine the meaning of a liberal education based on science.

Our work in educational renewal during the past two years has been based on the same premise as our examination of MIT research: our educational program must be better able to integrate different perspectives and approaches to learning, and be more attentive to the human contexts for scientific and technological endeavor. Clearly, the faculty does not hold a single or unified view as to what constitutes an ideal MIT education. And yet, faculty and students from virtually every department are coming together to ask hard questions about education at MIT—what to preserve, what to transform, what to create.

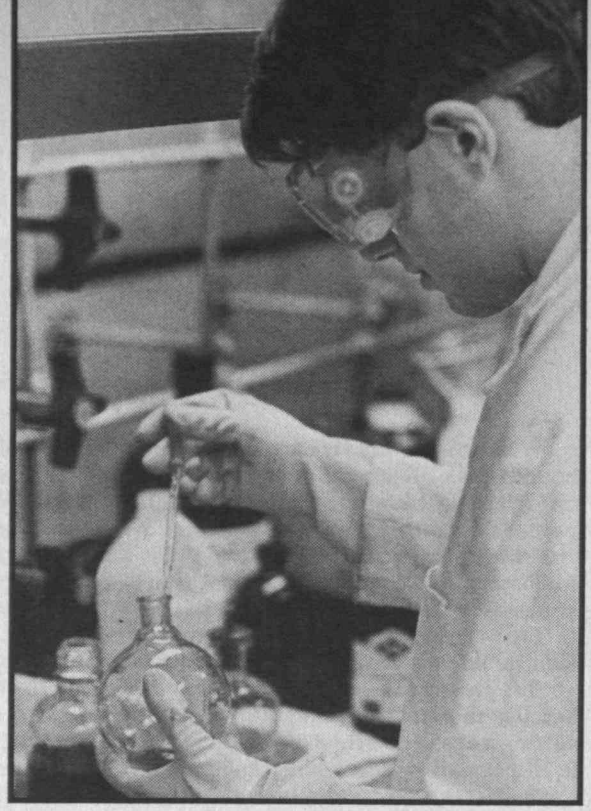
There is no escaping the fact that educational renewal is a difficult task, and we are conscious that we must not try to fix something that does not need fixing. At the same time, it has been a quarter century since the last large-scale and detailed review of the undergraduate program. Professor Jerrold Zacharias and members of the Committee on Curriculum Content Planning would have been the first to say that the future of science-based education is, like everything else, not what it used to be.

It seemed, therefore, appropriate to take another look. Curriculum reform, however, may not be the right label for the initiatives now under way. After all, the core requirements are already in place. They express a certain integrity and commitment to intellectual scope and depth and breadth. And I think we can take pride in the fact that an MIT undergraduate is expected to engage in a range of intellectual endeavor exceeding that of many of the great liberal arts universities. The challenge, therefore, is not so much one of reform, but of renewal. We need to assess and establish a new balance between the general and specialized aspects of the educational program. Within the core general education, we need to establish a new relationship between the humanities, social sciences (including management), and the arts on the one hand, and the sciences, mathematics, and technology on the other.

Beyond that—and here is the real challenge—we need to develop a true educational partnership among scientific, technological, artistic, social, and humanistic disciplines. This educational synergy cannot be addressed piecemeal by individual faculty members in separate disciplines.

The Review of Undergraduate Education: A Progress Report

This reassessment had important beginnings in the School of Engineering, where faculty have been concerned with the effectiveness of undergraduate engineering education for the 21st century, and in the School of Humanities and Social Science, where there is interest in taking fuller advantage of and contributing more fully to the unique character of an MIT education and the unique interests and capabilities of MIT students.



But faculty throughout the Institute have participated in this endeavor. This past year, the three Schools with major responsibilities in undergraduate education brought forth searching reports specifying changes and improvements. The reports came from the Commission on Engineering Undergraduate Education, from the Science Education Committee, and from the Institute Committee on the Humanities, Arts, and Social Sciences Requirements.

Under the leadership of the Faculty Committee on the Undergraduate Program, these separate perspectives gained the attention of the entire MIT community and began to converge. Emerging from the ideas in these reports, and from spirited community-wide debate and counterproposals, is a conception of a special breed of general education—an education that is MIT's own in definition and purpose.

The emerging common theme in faculty debate and committee work during this past year was a concept of a science-based liberal education. This concept recognizes and articulates MIT's tradition of equal commitment to science, mathematics, and technology on the one hand, and, on the other, to the humanities, arts, and social sciences—as expressed in the General Institute Requirements. This tradition is the foundation for taking the next steps toward integrating the components of the general undergraduate program.

Some of the next steps have been taken already:

- **Humanities.** This past year, the faculty voted a deceivingly modest change in the formulation of the Humanities, Arts, and Social Sciences Requirement, a component of the General Institute Requirements. The vote reaffirmed a commitment to the idea that concentration in one area and some degree of exposure to several areas was important. But the faculty also voted specific changes in the Distribution portion of the requirement. First, the previous formulation of categories of study in terms of traditional disciplines was swept away and replaced by five integrative categories emphasizing major themes cutting across disciplines. The categories are: Literary and Textual Studies; Language, Thought, and Value; the Arts; Cultures and Societies; and Historical Studies. Second, the explicit inclusion of the Arts as a category within the new framework represents a significant commitment by MIT to formal offerings in this area for our students. Third, the new Distribution subjects must be fundmanetal, that is, suitable for students who might never have another formal immersion in a given category of study.

- **Minors.** A second faculty action taken this year has potentially larger impact. For the first time in MIT history, the faculty established a provision for students to minor in an area of study. While the vote was specifically to provide for this option in the humanities, arts, and social sciences, we are likely to see similar provisions for minors in the sciences and possibly engineering and management in the course of time. Especially notable is the fact that this proposal was developed and accomplished through a partnership between the Schools of Engineering and of Humanities and Social Sciences. The Minor encourages and recognizes students who achieve a depth and rigor in one of the fields in humanities, arts, or social sciences that goes beyond the eight-subject minimum in the General Institute Requirements.

- **Engineering.** Last year, the School of Engineering's Commission on Undergraduate Education adopted a set of goals for the education of every student majoring in engineering at MIT, goals which could easily apply to the definition of a successful undergraduate education for any student here. In brief, the Commission concluded that with such as education, a student should have:

  - acquired a firm foundation in the sciences basic to his or her field,
  - begun to acquire a working knowledge of current technology,
  - begun to understand the diverse nature and history of human society,
  - acquired skills and motivation for continued self-education,
  - had the opportunity to participate in a research project,
  - had the opportunity for engineering synthesis on a design project,
  - developed oral and written communication skills, and

PHOTO: BRAD HERZOG

Central to our effectiveness is the excellence of our undergraduate education. The young men and women who come here as students . . . are the future.

- begun to understand and respect the economic, managerial, political, social, and economic issues surrounding technical development.

The School is continuing its work on assessing its undergraduate program, and these goals are informing the work on the larger review of undergraduate education at MIT.

The School of Engineering has also started a large-scale examination of the time demands of every engineering subject. Each instructor's subject is rated by students, with the results reviewed by department heads and by the School Council for possible action. The aim is to eliminate inappropriate demands, given the overall goals and objectives of the undergraduate program.

- **Bridging.** An MIT-style liberal education is likely to require specifically designed "bridging" or integrative experiences for all undergraduates. Such subjects would bring home to students the complexities, profundities, and interrelationships of the human contexts in which science and technical pursuits take place. All three curricular reports demonstrated excitement and commitment to the development of such experiences. Integration among fields cannot happen spontaneously, however. In order to come to some common view of the nature of bridging experiences and their role in the overall four-year program, we have embarked on a major curriculum development effort involving approximately 50 faculty from all five Schools. These faculty members are developing prototype integrative academic experiences for students. Three prototype efforts have been winnowed from this work to date and have been launched as accredited new subjects to be taught by teams of faculty from different schools.

- **Faculty Minicourses.** These bridging experiences are extremely difficult to develop and to mount. They require, first, that our faculty themselves have such academic experiences to draw on. The mechanism for doing this is a series of interdisciplinary minicourses for faculty, taught by faculty members. The first examples, in the past two summers, have been judged extremely effective. In the summer of 1986, the School of Engineering faculty hosted and ran an intensive one-week introduction to the structure and interpretation of computer programs for 30 faculty members from the School of Humanities and Social Science. That School reciprocated with a minicourse of lectures on contemporary world problems for 33 engineering faculty. This past summer, the course on world problems was offered again. The School of Science was the host for a minicourse on the frontiers of modern molecular biology, organized by the Biology faculty. A minicourse focusing on the epic in its ancient and modern guises, taught by the Literature faculty, was attended by faculty from all five Schools. More than 10 percent of the Institute's faculty attended these cross-School minicourses this past June.

- **Environment for Living and Learning.** As I reported last year, we are also developing some new programs to enhance the environment for living and learning at MIT, with a particular emphasis on encouraging more informal intellectual contact between students and faculty members. These activities include the creation of freshman seminars taught by faculty to their advisees, seminars in living groups, and advising clusters organized by living group. Particularly successful was the advisor-led seminar; we increased that program from eight to 33 seminars this fall, and still were unable to meet the demand.

  Also in the past year, we received the report of a faculty committee to review the housemaster-graduate resident system. This committee, chaired by the Dean of Engineering, made a number of recommendations for strengthening the residential program, includng a proposal for an MIT House Fellows Program, the goal of which is to promote greater interaction between students in Institute Houses and MIT faculty through a variety of informal non-academic activities. Under this program, which begins this coming year as a three-year experiment, each participating House will have five or six faculty House Fellows who will contribute to the intellectual and social life of the House through a variety of activities such as dramatic productions, athletic events, policy debates, musical performances or outings, or literary readings. In general, the role of the House Fellow would be to complement more formally academic House-based activities, such as the House seminars and team advising for freshmen.

During this coming year, a special faculty committee will study the first-year academic program. It will probe the academic experience and structure of that first year for all entering undergraduates. The aim is to provide a more intellectually invigorating and enabling first year. The freshman year is crucial because it establishes the student's view and understanding of the intellectual style and values of the academic community he or she has joined. MIT can do better in the first year than it has been doing. And so, the Committee on the First-Year Program will focus on the intellectual community, the calendar, the intensity, and pathways through the freshman year.

Also in the coming year, faculty will focus on the

science, mathematics, and technology component of MIT's core general education. Faculty deliberations so far point toward the need for an even stronger science foundation for our students. Although the extraordinary quality of MIT's life sciences faculty is widely recognized as the best in the country, if not the world, our requirements in science, mathematics, and technology do not contain the expectation that all undergraduates should be introduced to this area of knowledge.

MIT's assessment of its already strong core in science, mathematics, and technology comes when liberal arts colleges across the country are trying to strengthen and extend their typically meager science core, to create a program similar to that which has been traditional here. In these times, MIT's leadership is creating a balanced liberal education—containing more science; a renewed emphasis on the humanities, arts, and social sciences; and, potentially, integrative "contexts" courses—which may have a broad impact on American education.

* * *

These are but a few of the steps that we are taking along the path of educational renewal. Most of these steps have been taken by the faculty. Our success, however, will depend fully as much on the quality and character of our students as it does on the initiatives of our faculty. And perhaps the most dramatic progress in the process of educational renewal has taken place in Admissions. Our primary goal, of course, remains unchanged: to bring to MIT the most academically promising and interesting students with strong backgrounds in mathematics and science. We are, however, seeking more such students whose intellectual interests reach beyond science and engineering. In addition, we have been seeking to increase the percentage of women and minorities in our entering classes.

I can report progress on all fronts. Over the past two years, we have developed and begun to use a new system to evaluate applicants, we have embarked on a much more extensive school visits program, we have redesigned our recruiting publications, we established a new reception area for prospective students and their families, and have new programs and staff to attract and support minority students.

I can also report clear indications of success. For the Class entering this fall, we had the largest number of applicants in our history—7,300—of whom we admitted 25 percent. The Class of 1991 numbers just 1,001, with 85 percent of these students coming from the top five percent of their high school classes. The Director of Admissions reports that these students are characterized by broad academic interests, wide cultural diversity, and better racial balance than any previous group admitted to MIT. Moreover, their academic strength, as measured by grades and test scores, has increased over last year's class.

Judging from those students I have met already, I would venture to say that we will be challenged by them and stimulated by them in the best possible ways, as we seek to define an MIT education for the future. The culture they create, the academic interests they express, the plurality of perspectives they bring to this campus will be central to the character and quality of education during their years here and, I believe, in the educational programs that we are framing for future generations of students.

Campaign for the future

As I mentioned at the start of this report, the intensive examination and renewal of MIT's education and research programs have prepared us all for the great five-year effort to raise $550 million. This effort is aimed at mobilizing the resources MIT needs to achieve the potentials we see opening up—and which appear to us more as imperatives, things we must do, than merely as goals we hope to achieve.

All of us cooperating in the Campaign—above all the donors who will be joining our great effort—will be working together to provide the resources to give life to the visions that are taking concrete shape.

The resources we shall be mobilizing will reinforce the qualities of MIT that we cherish: the freedom, the flexibility, the trust and the expectation that we will do our very best—for our students, for the universe of knowledge, and yes, for the future. MIT has a pact with the future, a trust that we can make a difference in the world, a difference for the better.

What are the resources that will enable MIT to make this difference? As we fixed upon our specific goals for the Campaign, it became clear that this is a campaign for the fundamentals, for the very backbone of MIT. This Campaign is dedicated to strengthening our foundation, that is, the unique community of faculty and students that defines MIT.

And so our Campaign priorities are formulated in just those terms. In brief, they are:

PHOTO: DONNA COVENEY

Tidhar Shalon, '90, working on the 112-foot ultralight wing for the human-powered aircraft "Daedalus."

- **Faculty professorships.** We need to provide increased support and flexibility for our faculty to pursue the inspired and inspiring educational and research programs that have been a hallmark of MIT.
- **Funding for new academic initiatives.** These are opening up not only within, but among, our five Schools as faculty identify the complexities and interrelationships among the most interesting and pressing issues.
- **Financial support for students.** We must be able to provide reasonable levels of financial aid so that we can continue to attract and admit the very best students, without regard to their financial circumstances.
- **Funds for new undergraduate academic programs and for campus activities.** A more complete undergraduate life inside the classroom and out can be one of the most important results of this Campaign.
- **Facilities.** A new science complex, including new or renovated quarters for Biology, Physics, and Applied Biological Sciences, is our primary academic facilities goal. And housing for graduate students, long on our agenda, is an imperative for a research university of our caliber.
- **General Endowment.** Increasing our general endowment is a particularly high-priority goal. The income from such endowment provides the kind of financial flexibility and independence that allows us to seize the moment of opportunity in both education and research.

Participation of all—faculty, administration, alumni, trustees—is crucial to the success of the Campaign. The continuing study and discussions that have sparked the new activities in our education and research programs to date was essential in defining the goals for our drive. But they also bring us to the start of this effort with significant steps already achieved, and others in process. This is turn strengthens our confidence just when we need it most: on the eve of making our case to the world that the Campaign for MIT is the Campagin for the future.

In Special Recognition

The special character of MIT is highlighted every year in the achievements and honors of its faculty. While it is not possible to take note of every such distinction, there are some highlights which deserve mention.

The resources that we shall be mobilizing will reinforce the qualities of M.I.T. that we cherish: the freedom, the flexibility, the trust, and the expectation that we will do our very best.

In the spring the National Academy of Engineering elected three members of the MIT faculty to membership in the National Academy of Engineering. New MIT members are: Amar G. Bose and Alan V. Oppenheim, both Professors of Electrical Engineering and Computer Science, and Yao Tzu Li, Professor Emeritus and Senior Lecturer, Department of Aeronautics and Astronautics.

This past year two members of the faculty were elected members of the National Academy of Sciences. Those new MIT members are: Hermann A. Haus, Professor of Electrical Engineering and Computer Science, and Harvey F. Lodish, Professor of Biology.

Eight members of the MIT faculty were among those elected as Fellows of the American Academy of Arts and Sciences. New MIT members elected to the Mathematical and Physical Sciences section are: Albert R. Meyer and Joel Moses, Department of Electrical Engineering and Computer Science, Robert J. Birgeneau and Alan Guth, Department of Physics, and Satoru Masamune, Department of Chemistry. Elected to the Biological Sciences section are: Paul R. Schimmel and Alexander Varshavsky, Department of Biology. Elected to the Humanities section is John Harbison of the Music Section of the Department of Humanities.

Ioannis V. Yannas, Professor of Polymer Science and Engineering in the Department of Mechanical Engineering, was one of 40 new members elected to the Institute of Medicine.

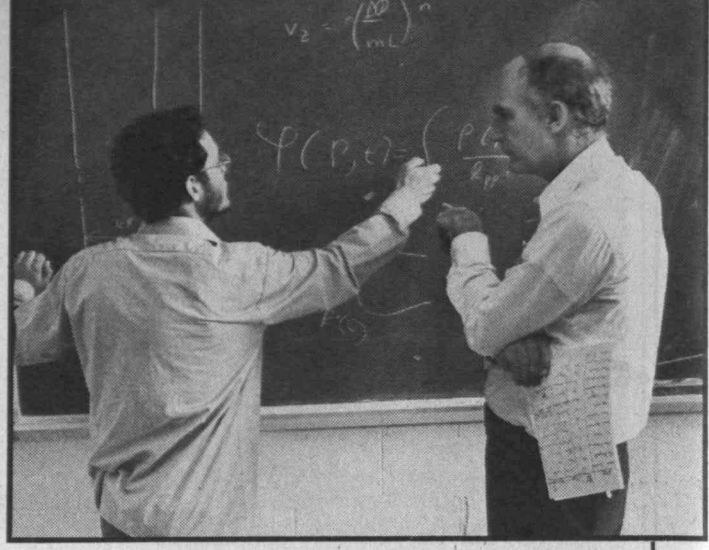
Har Gobind Khorana, Alfred P. Sloan Professor of Biology and Chemistry, was among the 20 persons who received the National Medal of Science in June 1987. Dr. Khorana received the Medal of Science for his "innovative contributions that significantly contributed to our understanding of gene structures, membrane function and vision."

In November Margaret L. A. MacVicar, Dean for Undergraduate Education, was awarded one of two 1986 Charles A. Dana Foundation prizes for "conceiving, designing and implementing" MIT's Undergraduate Research Opportunities Program. The Foundation presented the awards for the first time this year for achievement in the fields of health and higher education.

John Harbison, Professor in the Music Section, was awarded the 1987 Pulitzer Prize for musical composition in April 1987. He was recognized for his cantata "The Flight Into Egypt."

An Alexander von Humboldt Senior US Scientist Award and a Max Planck Society Award were presented to Brian J. Clifton, staff member in the Microelectronics Group at Lincoln Laboratory. The Humboldt awards are granted to outstanding US scientists in recognition of accomplishments in research and teaching.

Bruno B. Rossi, Institute Professor and Professor



Professor Hale Bradt (Department of Physics): modern astrophysics.

of Physics, Emeritus, was named a corecipient of the Wolf Prize in Physics for 1987 for his pioneering research in X-ray astrophysics. He shared the prize with Riccardo Giacconi of Johns Hopkins University and Herbert Friedman of the Naval Research Laboratory for their discovery of extra solar X-ray sources and related research.

Within the Institute, Hermann A. Haus, Elihu Thomson Professor of Electrical Engineering, was named an Institute Professor. The title of Institute Professor is an honor bestowed by the faculty on a colleague for leadership and distinguished accomplishments in the scholarly, educational, and general intellectual life of MIT and the wider academic community. Professor Haus has distinguished himself as both a scientist-engineer and teacher, praised by his colleagues for "his gift of bringing understanding to whatever he undertakes; his elegant theoretical formulation, lucid physical insight and thoroughness of approach; and the depth, sophistication and integrity of his research."

Jay W. Forrester, Germeshausen Professor Management, was selected as the 1987-88 recipient of the James R. Killian, Jr., Faculty Achievement Award. Established in 1971 as a tribute to Dr. Killian, MIT's tenth President and former Chairman of the Corporation, the award recognizes extraordinary professional accomplishments and service to the Institute. The committee's citation said in part: "Jay is a pioneer. He is one of those rare individuals who possess not only the intellect and imagination to see the path ahead, but the skill and the stamina to lead the journey."

In the late spring, Sylvia T. Ceyer, Assistant Professor in the Chemistry Department, was named the 1987 recipient of the Harold E. Edgerton Faculty Achievement Award. The award is given annually to a junior faculty member who has made outstanding contributions in research, teaching, and service to the MIT community. The selection committee in its citation noted that she is "an accomplished scholar and a talented and innovative experimentalist."

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This past year, several key leadership roles at the Institute changed, and those transitions were occasion for special recognition.

Lester C. Thurow, Gordon Y Billard Professor of Management and Economics, was named dean of the Sloan School of Management effective July 1987. He succeeds Abraham J. Siegel, who has served as dean since 1980 and is returning to teaching and research. Professor Thurow's research and writing has focused primarily in the areas of income distribution economics, public finance, and international economics.

New department or program heads appointed or announced during the past year are: Rafael L. Bras, Director, MITES (Minority Introduction to Engineering and Science) Program; Mario L. Gnecco, Director, Management of Technology Program; John H. Harbison, Head, Music Section, Department of Humanities; Arnoldo C. Hax, Deputy Dean, Sloan School of Management; James Howe, Head, Anthropology and Archaeology Section, Department of Humanities; Philip S. Khoury, Associate Dean, School of Humanities and Social Science; Thomas L. Magnanti, Codirector, Operations Research Center; Tod Machover, Director, Philippe Villers Experimental Media Facility; Amedeo R. Odoni, Codirector, Operations Research Center; William L. Porter, Interim Head, Architecture; Glen L. Urban, Deputy Dean, Sloan School of Management; Myron Weiner, Director, Center for International Studies; and Mark S. Wrighton, Head, Department of Chemistry.

Bernard J. Frieden, Professor of Urban Studies and Planning, was elected to head the MIT faculty and Sallie W. Chisholm, Professor of Civil Engineering, was elected associate chairman of the faculty. Jack Ruina will continue to serve as secretary.

Major changes in the Institute's central administration during the year included the appointment of Arnold Weinberg as Medical Director and David S. Wiley as Registrar.

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The Institute was saddened this year by the deaths of several longtime friends and colleagues. We miss them and are grateful for their contributions to this community.

David Adler, professor of electrical engineering and a renowned solid-state physicist, died in March of 1987 at the age of 51. Dr. Adler joined the MIT faculty in 1967 and achieved recognition for his outstanding undergrduate teaching and extensive work on the physics of amorphous semiconductors. He was widely published and was an important contributor to the development and operation of the Concourse Program at MIT.

Former MIT professor Eugene W. Boehne died at 81 in February of 1987. Professor Boehne joined the MIT faculty in 1947 and taught in the Department of Electrical Engineering until his retirement in 1960.

Professor emeritus of biochemistry Bernard S. Gould died at the age of 75 in February 1987. He was a 1932 graduate of MIT. During his nearly 40 years on the MIT faculty, until his retirement in 1977, he specialized in the biochemistry of wound healing, tissue regeneration, and the role of vitamins in these processes.

Ida M. Flansburgh Green died in December of 1986 at the age of 83. Along with her husband Cecil, she

PHOTO: BRAD HERZOG

We have been enormously successful in gathering together the resources—the people, funding, and facilities—that have enabled us to create a great research university.

made extraordinary philanthropic contributions to the Institute, including the funding of numerous professorships and the Ida Green Fellowships for graduate women, and the endowing of the Green Building where the Department of Earth, Atmospheric, and Planetary Sciences is housed. Mrs. Green became a Member of the MIT Corporation in 1979 and was honored with the name of the Ida M. Flansburgh Green Hall for graduate women in 1983. She was an honorary member in the Association of MIT Alumnae.

Edward Neal Hartley died in December of 1986 at age 72. A former member of the History faculty and head of the Institute Archives, he was on the MIT faculty for 31 years until his retirement in 1977.

Paul F. Hellmuth, aged 68, died in August of 1986. A member of the MIT Corporation from 1974 to 1979, he was associated with the Boston law firm of Hale & Dorr and was cochairman of the MIT Leadership Campaign.

Elizabeth Parks Killian, wife of former MIT president, James R. Killian, Jr., died at the age of 79 in November of 1986. A 1929 graduate of Wellesley College, Mrs. Killian's enthusiastic involvement in MIT activities spanned many decades and included especially the years during her husband's terms as MIT president and as chairman and honorary chairman of the MIT Corporation.

In August of 1986 professor emeritus of the Department of Physics, M. Stanley Livingston, died at the age of 81. Professor Livingston joined the MIT faculty in 1938, built MIT's first cyclotron, and was involved in undergraduate teaching and in the design and construction of cyclotrons and high-voltage accelerators for studying atomic physics. Professor Livingston retired from the Institute in 1970.

Avery A. Morton died in March of 1987, at the age of 94. Professor Morton came to the Institute in 1920 as an instructor in organic chemistry, receiving his Ph.D. degree in 1924. In 1940 he became full professor and director of the research laboratory of organic chemistry. He retired from MIT in 1958.

Clint W. Murchison died at age 63 in March of 1987. Mr. Murchison received his S.M. degree in mathematics from MIT in 1944 and had been a member of MIT Corporation since 1972 and a Life Member since 1977. His entrepreneurial achievements ranged from insurance and banking to publishing and professional sports, an interest which in 1960 led him to found the Dallas Cowboys.

Frederick H. Norton, a 1918 graduate of MIT in physics, died in November 1986 at the age of 90. Professor Norton was internationally recognized for setting forth the principles leading to the establishment of ceramics as an important science and authored the first standard text in this field. In 1927 Professor Norton returned to MIT to join the faculty in the Department of Materials Science and Engineering; he headed the Ceramics Division for many years and retired in 1962.

Internationally known Slavic literature scholar Krystyna Pomorska died in December 1986 at the age of 58. The author of several books and hundreds of articles, Professor Pomorska came to MIT in 1963 where she pursued her work in Slavic poetry and 19th- and 20th-Century Russian literature. With her late husband and former MIT faculty member, Roman Jakobson, she coauthored *Dialogues*, an account of Professor Jakobson's life.

Professor emeritus Brandon G. Rightmire died in January 1987 at age 75. He received the Sc.D. in mechanical engineering from MIT in 1941 and joined the MIT faculty in 1942. His interest lay in fluid mechanics, applied dynamics, and thermodynamics, and he coauthored the text *Engineering Applications of Fluid Mechanics*. He retired in 1976.

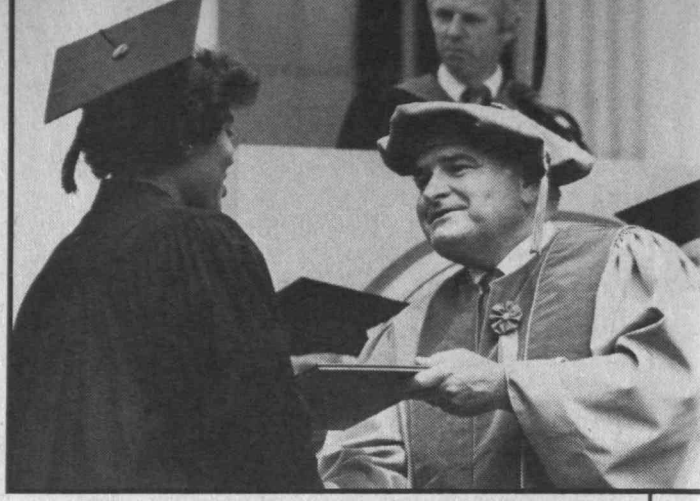
In April 1986 George P. Wadsworth died at the age of 78. Professor Wadsworth received the S.B. (1930), S.M. (1931), and Ph.D. degrees (1933), all from MIT, and for 39 years until his retirement in 1974 served in the Department of Mathematics, making significant contributions through his work in probability and statistics to meteorological forecasting; oil exploration; and operations, medical, and ocean wave research. He authored several textbooks and was actively involved in undergraduate education at the Institute.

Zenon S. Zannetos, 59, professor of management at the Sloan School of Management, where he was affiliated for more than 30 years, died in May 1987. He completed the S.M. and the Ph.D. at MIT in 1955 and 1959, respectively, and was known for his work in oil economics. He became a member of the MIT faculty in 1961, developed and taught in the Executive Development Program at Sloan, served as Chairman of the Senior Executive Program Committe, and most recently served as Senior Associate Dean for Development.

Physical Plant and Campus Environment

This year saw the completion of the Philippe Villers Experimental Media Facility in the Wiesner Building, and several successful productions were held in the space by year-end. On the West Campus, a new state-of-the-art, multi-use artificial turf playing field was installed adjacent to the J. B. Carr Tennis Facility. In addition, the Carr Tennis Facility air-supported enclosure was replaced with one having better insulating qualities, improved lighting characteristics, and a longer projected life.

New projects initiated during the year included a major renovation of the Stratton Center where a variety of retail stores, a new food court, and numerous other major changes will be introduced; the conversion of the former Hayden Gallery in the Hayden Library to the Elizabeth Parks Killian Hall, a



space where the School of Humanities and Social Science can schedule music performances, seminars, and other school functions; and renovations to the east wing of Ashdown House which, when completed, will provide living accommodations for an additonal 30 graduate students. In addition, following years of study, approval was received to proceed with the permitting and preliminary design phases of a combined-cycle cogeneration facility to be located in our existing Central Utilities Plant on Vassar Street. Upon completion, this facility will generate 28 megawatts of power for sale to the local utility and will produce base load campus heating steam for most of the year, thereby enabling us to take our two oldest boilers out of service. Projected savings over the life of the project are substantial.

Three land acquisitions made during the year are worthy of note, namely the purchase of the TRW property at the corner of Main and Ames Street, the F&T Restaurant and Diner, and the Cambridge Press properties in Kendall Square. These three pivotal acquisitions will now enable us to plan for an orderly expansion of our academic activities in this vital area of the campus.

A sample of programs initiated during the year that could directly affect MIT's environment include a systematic process of identifying all remaining asbestos-containing materials on campus and the identification of all remaining equipment that contains PCBs. Once these identification processes are completed, abatement programs will be initiated. In addition, the first phase of a program to identify and catalogue historical subsurface datum points, including ground water survey wells and settlement pins, was completed. This program, which builds on the old Foundation Experimentation Research project (FERMIT) carried out by the Soils Engineering Group of the Civil Engineering Department in the 1960s and 1970s, will provide valuable data for monitoring the condition of the 6,000 wood piles which support original campus buildings.

Career Services and Preprofessional Advising

Notwithstanding lean times in many industries, slow growth in others, corporate "downsizing," corporate mergers, and a leveling-off in the growth of defense spending, more companies and government agencies came recruiting than a year ago. A total of 423 employers made one or more visits, compared with 395 in 1985-86. The total in 1984-85 was slightly higher, 431. The discipline most often requested was electrical engineering, followed closely by computer science. Mechanical engineering was requested two-thirds as often as electrical engineering; chemical engineering, materials science and engineering, and aeronautics and astronautics were requested one-third as often.

While the level of recruiting activity was high, this interest was not always reflected in the number of offers reported and in salaries. For example, seniors in electrical engineering and computer science reported a third fewer offers. There were also fewer offers to master's degree candidates in aeronautics and astronautics and in chemical engineering. On the other hand, there were more offers to seniors in management. Meanwhile, salaries grew only slightly from a year ago. For example, salaries offered to seniors in electrical engineering and computer science were up less than three percent (to a median of $31,020); offers to seniors in chemical engineering were up less than two percent (to $30,480); offers to Ph.D. physicists were up one percent (to $45,000). The highest offers were to Ph.D.'s in electrical engineering, up 6.5 percent to $51,000. It was a good year for students with computer skills. Offers to seniors in computer science (up four percent to $31,320) exceeded for the first time offers to seniors in electrical engineering.

The number of MIT applicants to medical school declined, matching a decline in the nation. They totaled 112, compared with 123 in 1985-86. They included 65 seniors, 1 graduate student, and 46 alumni. As of the first of July, 54 seniors had been accepted (83 percent), the one graduate student, and 37 of the alumni (80 percent). The overall acceptance rate at this preliminary stage was 82 percent.

Finances

As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, amounted to $882,484,000, an increase of 11 percent over 1985-86. Education and general expenses—excluding the direct expenses of departmental and interdepartmental research and the Lincoln Laboratory—amounted to $359,896,000 during 1986-87, compared to $332,211,000 in 1985-86. The direct expenses of departmental and interdepartmental sponsored research on campus increased from $179,648,000 to $184,526,000; and direct expenses of the Lincoln Laboratory's sponsored research increased from $280,063,000 to $338,062,000.

Current revenues used to meet the Institute's operating expenses total $879,384,000, augmented by $3,100,000 in unrestricted gifts. After meeting these expenses, a surplus of$1,175,000 in current unrestricted gifts was held at year-end.

The Institute made only modest additions to facilities and the book value of educational plant facilities increased from $321,681,000 to $327,406,000.

PHOTO: JIM HARRISON

For the class entering this fall, we had the largest number of applicants in our history—7,300—of whom we admitted 25 percent.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, students' notes receivable, and amounts due from educational plant, had a book value of $917,464,000 and a market value of $1,396,716,000. This compares to book and market values of $784,089,000 and $1,175,678,000 last year.

Gifts

Gifts, grants, and bequests to MIT from private donors increaed by 25 percent in 1986-87 to $68,331,000, as compared to $54,783,000 in 1985-86. The Alumni Fund reported gifts of $13,686,000 for the year, another record.

Statistics for the Year

The following paragraphs report briefly on various aspects of the Institute's activities and operations during 1986-87.

Registration

In 1986-87 student enrollment was 9,756, compared with 9,787 in 1985-86. This total comprised 4,443 undergraduates (compared with 4,541 the previous year), and 5,313 graduate students (compared with 5,246 the previous year). Graduate students who entered MIT last year held degrees from 352 colleges and universities, American and foreign. The international student population was 1,896 (not including permanent residents), representing 7 percent of the undergraduate and 30 percent of the graduate population. These students were citizens of 90 countries.

In 1986-87 there were 2,340 women students (1,295 undergraduate and 1,045 graduate) at the Institute, compared with 2,218 (1,176 undergraduate and 1,042 graduate) in 1985-86. In September 1986, 378 first-year women entered MIT, representing 38 percent of the freshman class.

In 1986-87 there were 1,344 minority students (1,124 undergraduate and 220 graduate) at the Institute, compared with 1,241 (1,047 undergraduate and 194 graduate) in 1985-86. Due to changes in Federal guidelines, the numbers for 1986-87 include students with permanent residence status; those for 1985-86 do not. Minority students in 1986-87 included 300 Blacks (non-Hispanic), 21 Native Americans, 265 Hispanics, and 758 Asian Americans. The first-year class entering in September 1986 included 302 minority students, representing 30 percent of the class.

Degrees Awarded

Degrees awarded by the Institute in 1986-87 included 1,159 bachelor's degrees, 1,150 master's degrees, 42 engineer's degrees, 459 doctoral degrees—a total of 2,810.

Student Financial Aid

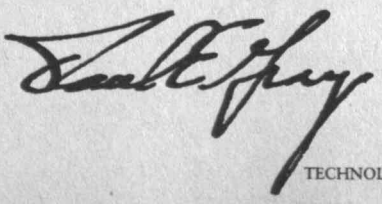
During the academic year 1986-87, the student financial aid program was again characterized by an increase in the overall need for financial aid and in the aggregate amount of grants made available. There was a decrease in the amount of MIT loans awarded, in the face of a significant increase in the amount of National Direct Student Loans made. Guaranteed Student Loans obtained from commercial sources showed a notable decrease.

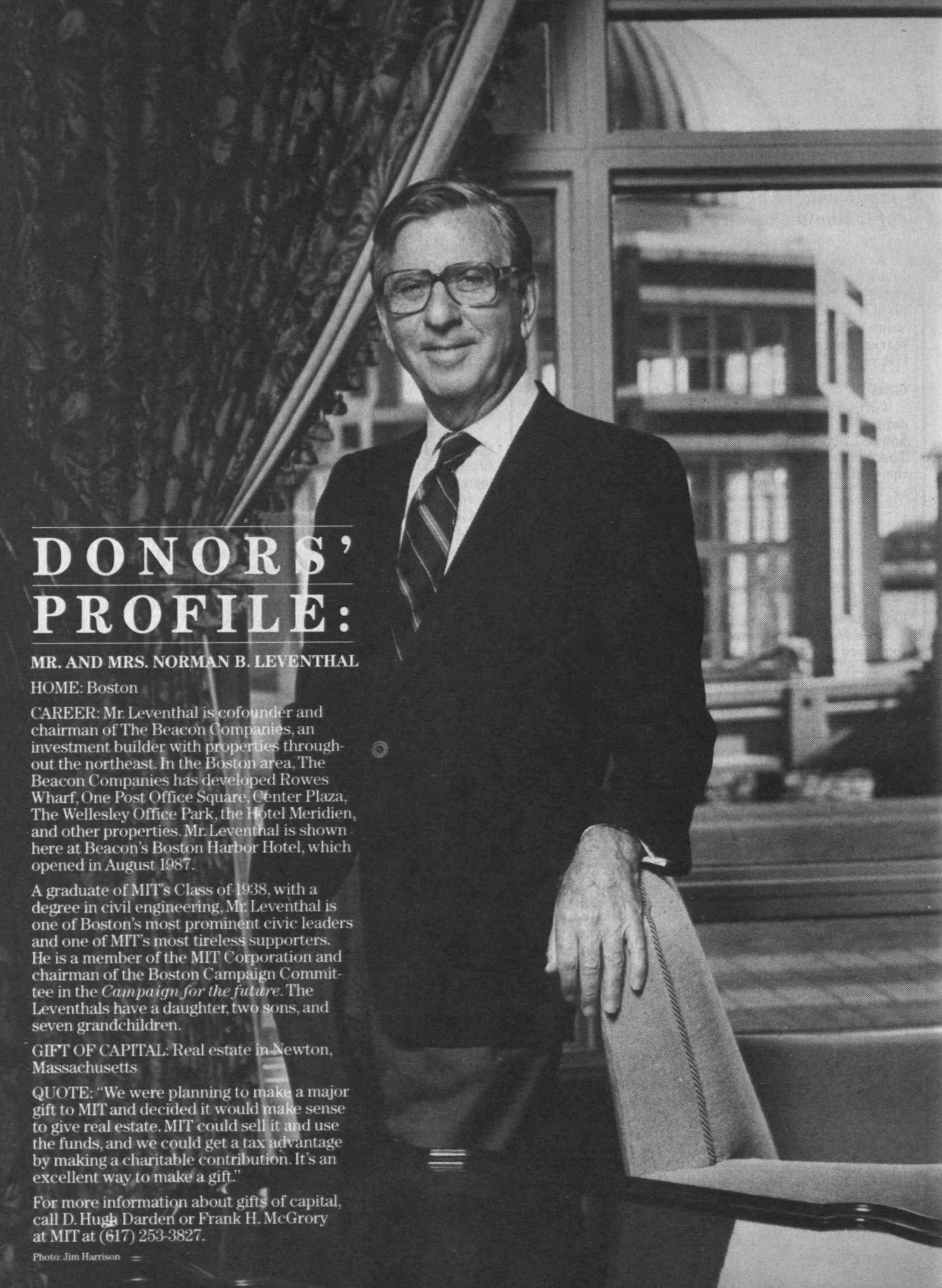
A total of 2,360 undergraduates who demonstrated the need for assitance (53 percent of the enrollment) received $16,209,000 in grant aid and $3,610,000 in loans. The total, $19,819,000, represents a 5 percent increase in aid compared to last year.

Grant assistance to undergraduates was provided by $4,813,000 in income from the scholarship endowment, by $2,067,000 in outside gifts and Federal allocations to MIT for scholarships, and by $3,208,000 in direct grants from outside sources, including ROTC, to needy students. In addition, $6,121,000 in scholarships from MIT's unrestricted funds was provided to undergraduates, inclusive of the special program of scholarship aid to minority group students, which represented $164,000 from unresricted funds. An additional 709 students received grants from outside agencies, irrespective of need. The undergraduate scholarship endowment was aided by the addition of $6,284,000 in new funds, a new high that raised the principal of the endowment by 16 percent, to $46,422,000.

Loans totaling $3,610,000 were made to needy undergraduates—a 10 percent increase from last year. Of this amount, $766,000 came from the Technology Loan Fund and $2,844,000 from the National Direct Student Loan Fund. Not included in the foregoing summary is an additional $4,834,000 obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources.

Graduate students obtained $1,198,000 from the Technology Loan Fund, $357,000 of which was loaned to international students and did not qualify for the Federal interest subsidies and guarantees available under the Guaranteed Student Loan Program. In addition, $56,000 was loaned by MIT under the Guaranteed Student Loan Proram. The total, $1,254,000, represents a 17 percent decrease from last year's level. Graduate students obtained $3,350,000 from outside sources under the Guaranteed Student Loan Program—about the same as last year. The total loaned by MIT to both graduate and undergraduate students was $4,864,000, a 2 percent increase over last year.





DONORS' PROFILE:

MR. AND MRS. NORMAN B. LEVENTHAL

HOME: Boston

CAREER: Mr. Leventhal is cofounder and chairman of The Beacon Companies, an investment builder with properties throughout the northeast. In the Boston area, The Beacon Companies has developed Rowes Wharf, One Post Office Square, Center Plaza, The Wellesley Office Park, the Hotel Meridien, and other properties. Mr. Leventhal is shown here at Beacon's Boston Harbor Hotel, which opened in August 1987.

A graduate of MIT's Class of 1938, with a degree in civil engineering, Mr. Leventhal is one of Boston's most prominent civic leaders and one of MIT's most tireless supporters. He is a member of the MIT Corporation and chairman of the Boston Campaign Committee in the *Campaign for the future*. The Leventhals have a daughter, two sons, and seven grandchildren.

GIFT OF CAPITAL: Real estate in Newton, Massachusetts

QUOTE: "We were planning to make a major gift to MIT and decided it would make sense to give real estate. MIT could sell it and use the funds, and we could get a tax advantage by making a charitable contribution. It's an excellent way to make a gift."

For more information about gifts of capital, call D. Hugh Darden or Frank H. McGrory at MIT at (617) 253-3827.

Photo: Jim Harrison

"Nuclear magnetic resonance imaging" is the one large-scale superconductor application now commercially available. It uses the magnetic properties of the protons of hydrogen atoms to generate detailed images of the body's soft tissues.

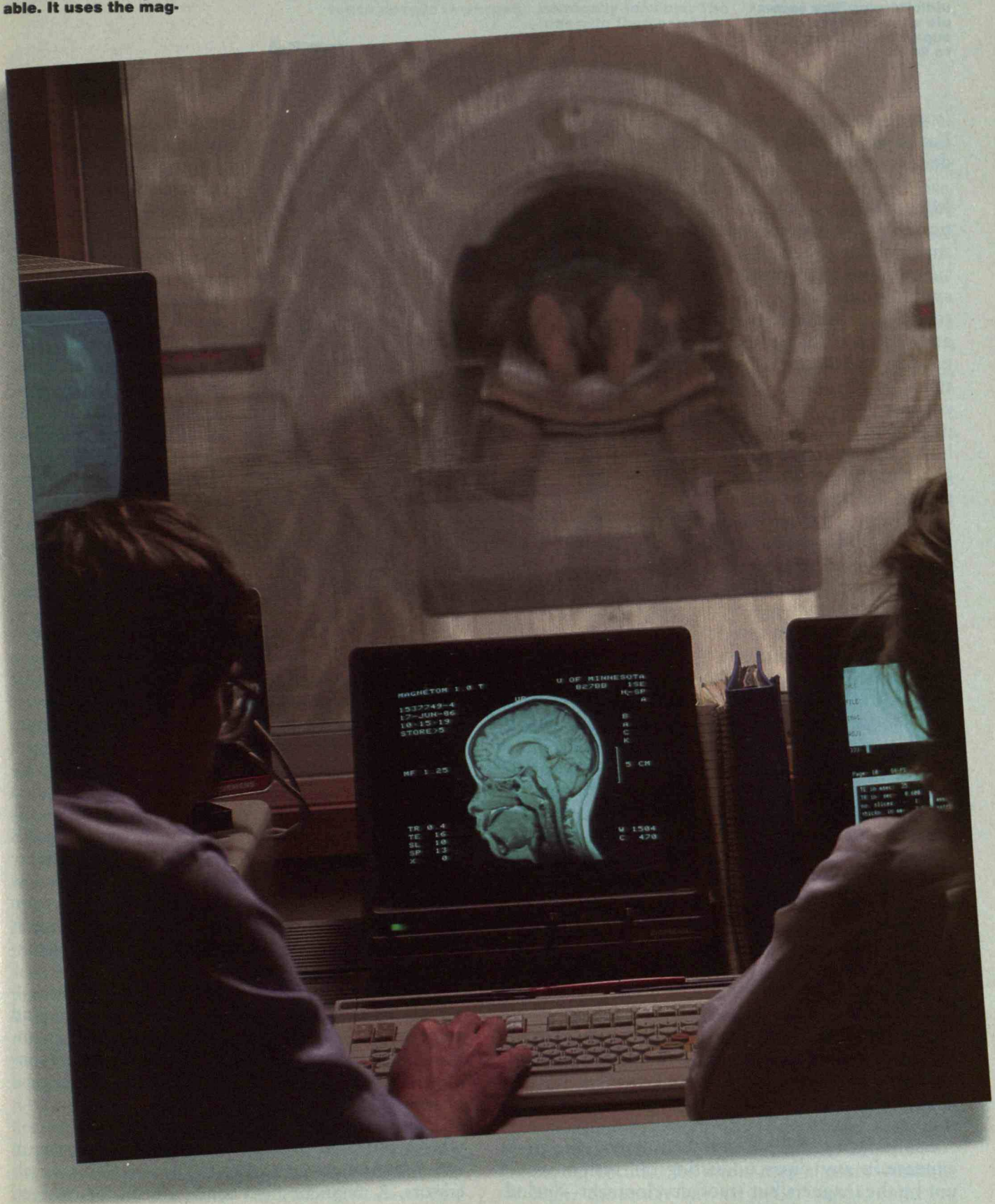
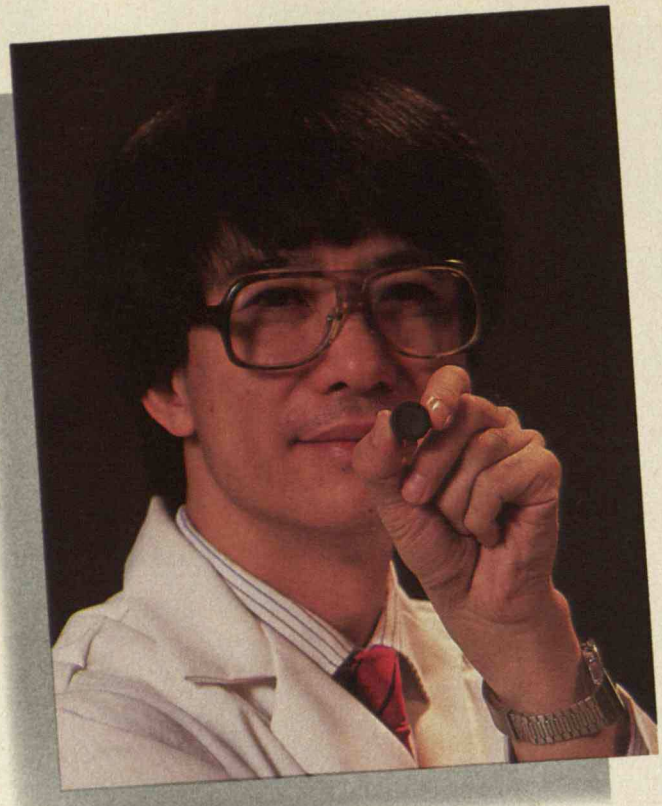


PHOTO: PAUL SHAMBROOM TECHNICAL CONSULT: J. C. KRYDER, M.D.



The University of Houston's Paul Chu holds the first ceramic capable of superconducting above the temperature of liquid nitrogen. The sample showed signs of superconductivity at up to 94 K.

(continued from page 40)

Large-Scale Superconducting Applications

Most large-scale applications involve the use of superconductors in capital-intensive technical systems, such as railroads, power generation and transmission, and particle accelerators. Because of their scale and expense, they would almost without exception have to be undertaken by government or by controlled monopolies such as utilities, and would depend on public-policy decisions for funding. Most are technically feasible with conventional superconductors, but the superconducting component of the system is a relatively small part of the total cost. Therefore, the potential savings from using high-temperature superconductors would also be small.

A case in point is one of the classic examples used to suggest the technological potential of superconductors—magnetically levitated (MAGLEV) trains. No article in the popular press about superconductivity fails to refer to super-fast trains floating from city to city on a cushion of magnetic field provided by superconducting magnets.

MAGLEV technology has been studied extensively during the past decade, and prototypes using conventional superconductors made from niobium-titanium and cooled by liquid helium have been built and tested in Japan and West Germany. At about 20 miles per hour, the superconducting magnets on the train induce enough current in a conducting trackway to produce a repulsive force that levitates the train. In unmanned tests, the Japanese MAGLEV prototype has reached 320 miles per hour.

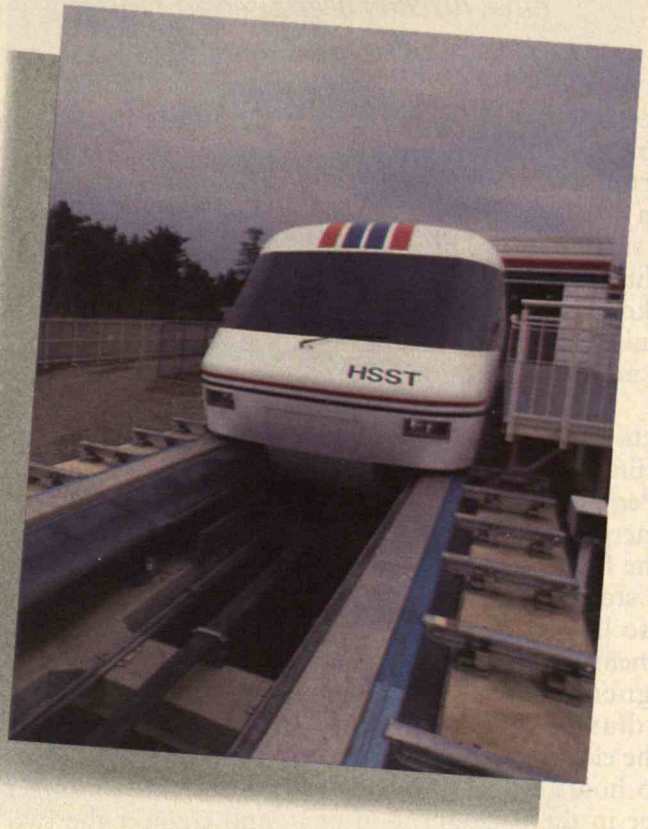
Economic feasibility is another matter. The major expense in any superconducting rail system would not be the magnets but track development—including purchasing the right-of-way, preparing the roadbed, building bridges, and laying track. Stringent limits on track curvature and gradient increase the costs of high-speed trains. (*See "High-Speed Rail," April 1986, page 32.*) For example, between 1975 and 1982, capital costs for the Japanese bullet train that runs between Tokyo, Osaka, and Hakata were between $30 million and $40 million per mile. And because track geometry must be so precise, maintenance is expensive. It is likely that capital and operating costs for a MAGLEV train would be in the same range as those for the bullet train.

Such massive investments would require a major public commitment to high-speed public transportation. Moreover, even if federal or state governments were to decide to create a rapid-train system in the United States or in a single region, there are alternatives to MAGLEV technology. For instance, the French TGV (*Train à Grande Vitesse*) is a proven technology using conventional steel rails and wheels instead of magnets. It travels at speeds up to 180 miles per hour—slower than the Japanese MAGLEV prototype, true, but the technology is less risky. And should an American version of the train ever be built, chances are it would move passengers through the Northeast Corridor fast enough to compete with other modes of transportation.

In the face of these major public-policy decisions—whether to build a high-speed rail system and whether to use MAGLEV technology for it—it is unlikely that the savings high-temperature superconductors might make possible will be the critical economic factor.

A similar example is one large-scale application where conventional superconductors are already in use. Magnets are central to high-energy ring accelerators. A magnetic field bends a beam of charged particles in a roughly circular path as they travel at

PHOTO: DAN FORD CONNOLLY/PICTURE GROUP



Japanese engineers have built this experimental levitating train, which uses superconducting magnets to reach speeds in excess of 300 miles per hour. However, constructing an actual rail system based on the new technology may not be economically feasible. The magnets themselves represent a relatively small part of total costs, but the expenses associated with track development could reach tens of millions of dollars—per mile.

nearly the speed of light around the circumference of the accelerator. The higher the field, the higher the energy level achievable over a given circumference—and the smaller the circumference necessary for a given level of energy.

Ring accelerators always used to employ iron-core magnets. In the early 1980s, however, Fermilab in Batavia, Ill., built a superconducting accelerator in the same tunnel as the iron-core Tevatron accelerator. This doubled the energy level while avoiding the construction costs of a new tunnel.

Recently, the high-energy physics community has proposed a Superconducting Super Collider (SSC). The plan calls for a high-energy accelerator approximately 53 miles in circumference and operating at a field of 6.6 tesla generated by some 10,000 superconducting magnets made of niobium-titanium and cooled to the temperature of liquid helium. The SSC is estimated to cost between $4.4 billion and $6 billion.

Why not use higher-field superconducting magnets—whether conventional or high-temperature—to create accelerators with smaller circumference and save on construction costs? Unfortunately, there are technical problems with this scenario. When a current is carried in a superconducting wire, the field interacts with the superconductor, producing powerful forces that can tear the magnet apart. Magnets must be engineered with structures that hold the wires in place. Moreover, because the force increases as the square of the field—for example, when the field doubles, the forces are four times as great—higher fields require much larger amounts of supporting structure. This adds to the cost. So does the fact that, as the field increases, current density decreases. The lower the current density, the more superconducting material necessary to generate the magnetic field. Thus, any superconducting magnet is the product of a compromise. The designers of the SSC have concluded that 6.6 tesla is optimum.

If high-temperature superconductors are perfected, it would be technically possible to save money on cooling. But as with the example of the MAGLEV train, the savings would be relatively minor. The estimated cost of the superconducting magnets and cooling for the SSC is approximately $250 million, only 5 percent of the total cost.

Finally, it could well be that liquid helium will be necessary in the SSC no matter what kind of superconductors are used. Liquid helium's intense cold helps to maintain the ultrahigh vacuum necessary to prevent speeding particles from colliding with air molecules or other impurities.

The one large-scale application not based on generating high magnetic fields—superconducting power transmission—also faces economic obstacles. In 1985, the United States consumed $175 billion worth of electricity, sustaining about $8.75 billion in transmission losses, or approximately 5 percent. Robert Jaffe of the Electric Power Research Institute in Palo Alto, Calif., has estimated that superconducting transmission lines might generate a saving of perhaps $5 billion per year. But the capital costs of installing such lines, Jaffe points out, might be hundreds of billions of dollars.

One problem of superconducting power cables is that because they would have to be refrigerated, they would almost inevitably go underground. The significance of this is that over long distances, overhead transmission wires are from 10 to 30 times cheaper to construct than underground cables.

Second, because the initial capital costs would be so high, the only way to make superconducting power transmission cost-effective would be by send-

PHOTO: CLAUDE CHARLIER

Superconducting ceramics have already been used in prototype electronic devices.

ing large quantities of electricity over a given line. This is technically possible, and the prospect has inspired numerous predictions of entire cities serviced with electricity from a single superconducting cable. But to depend on a single cable to provide the needs of a large metropolitan region is to risk massive disruption from breakdowns or power outages. At the least, it would require adding significant overcapacity—which would add to the cost of the entire system.

Superconducting magnets can also be used to store energy without any loss. Energy is held in the field generated by a magnet. Periodically, the magnet is discharged, feeding the energy back to the original source used to generate the field.

Superconductor energy storage might be feasible for utilities, but only on so large a scale as to be a substantial capital investment. To be cost-effective, an energy-storage magnet would have to be hundreds of meters in diameter—able to hold enough power to supply the electricity needs of New York City for one to two hours. The capital costs of such a system would be in the neighborhood of a billion dollars.

What about using the same technique to store smaller amounts of energy—for example, enough to power vehicles such as automobiles? Unfortunately, this idea has a fundamental flaw. To store enough energy for an automobile engine, you would still need an absurdly large magnet. A magnet weighing about 100 pounds could store enough energy to generate about 130 horsepower—but only for one second.

Nuclear magnetic resonance (NMR) imaging, which uses the magnetic properties of the protons of hydrogen atoms to generate detailed images of the human body's soft tissues, is the one large-scale superconducting application currently on the commercial market. (*See "NMR: The Best Thing Since X-Rays?" January 1988, page 58.*) This is one area where high-temperature superconducting magnets could make some difference.

A typical NMR machine costs from $1 million to $2 million, and the superconducting magnet costs approximately $200,000 to $300,000. Another $100,000 goes toward insulating the magnet, and the liquid helium necessary to cool it accounts for about $30,000 of the roughly $100,000-plus annual operating cost.

Liquid-nitrogen coolant for high-temperature superconductors would cost considerably less—around $2,500 per year. Depending on the cost of the superconducting ceramics and other materials used, some savings might also be possible for the magnet and the insulation, but the ceramics are likely to be expensive because of the technical problems with fabricating magnets out of a brittle material.

Superconductor Electronics

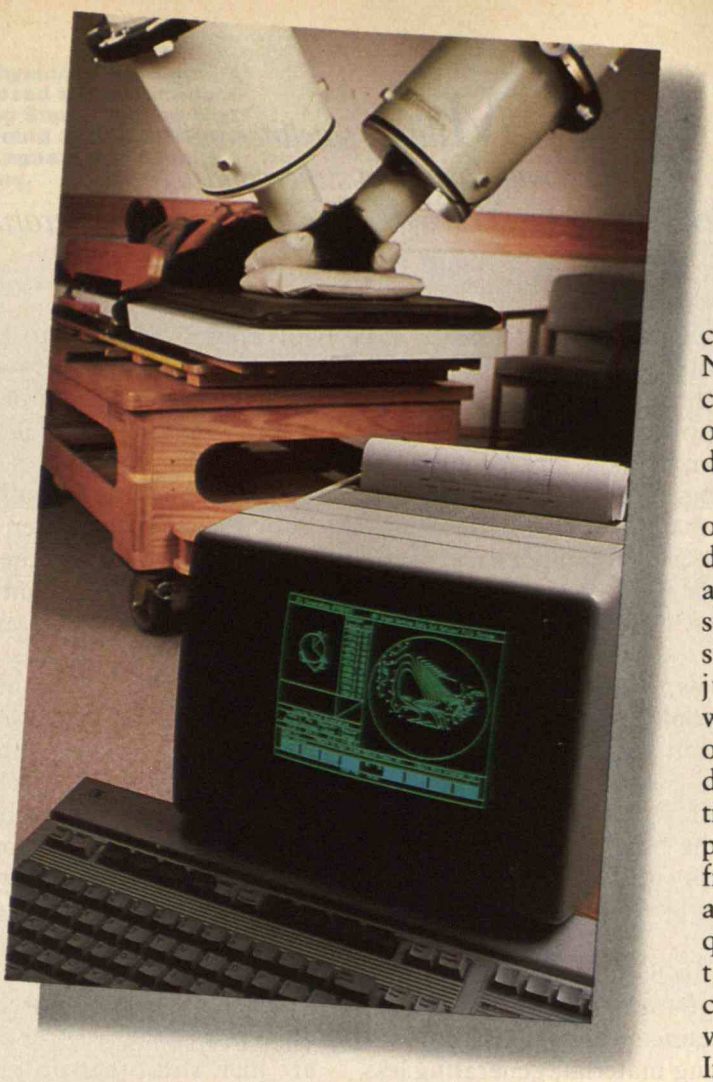
Small-scale applications of superconductors are less visible but far more common than their large-scale counterparts. They define a field sometimes known as "superconductor electronics." At present all commercially available superconducting electronic products are based on a phenomenon of superconductivity known as "tunneling."

To understand tunneling, consider two superconductors separated by an insulating barrier such as silicon or an oxide. As British physicist Brian Josephson predicted in 1962, a superconducting current is able to tunnel through the insulating barrier and connect the two superconductors without any resistance. Josephson also showed that the amount of current able to tunnel across the barrier had a maximum value that could be controlled by a very small magnetic field. This made it possible to use what have come to be called "Josephson junctions" as extremely sensitive detectors of magnetic field.

Superconducting quantum interference devices, or SQUIDs, use the extreme sensitivity of Josephson tunneling to measure fields a thousand times smaller than is possible with any non-superconducting device. The SQUID doubles as a voltmeter, able to detect voltages as low as a billionth of a billionth of a volt and currents as small as 10 electrons per second passing through a wire.

One important application of SQUIDs is in biomedical research. (In fact, the sole domestic manufacturer of SQUID technology is Biomagnetic Technologies of San Diego, Calif., which serves the health field.) Employed in the process known as "magnetoencephalography," the magnetometer measures small magnetic fields produced by the firing of neurons in the brain. Magnetoencephalography has two advantages over its electrical counterpart, electroencephalography (EEG). It is completely noninvasive and can locate the sources of specific signals in the brain.

Geologists also use SQUID magnetometers to de-



This "superconducting quantum interference device" measures small magnetic fields produced in the brain. Such highly specialized electronic instruments are among the most common superconductor applications so far.

tect the magnetic properties of rock samples, and to locate geological faults or explore for oil, water, and mineral deposits. Another application derives from the phenomenon of "paleomagnetism," which allows researchers to date a portion of the earth's crust by determining the direction of its magnetic field. In addition, it may be possible to use SQUIDs for defense purposes—for example, to detect sudden changes in the earth's magnetic field caused by submarines.

In 1960, the American physicist Ivar Giaever discovered a different kind of tunneling. Whereas Josephson tunneling occurs without any resistance, allowing a current to flow across the insulating barrier at zero voltage, Giaever tunneling does not occur *until* a certain voltage is reached. The voltage causes some of the electrons in the material to return to a non-superconducting state, at which point they are able to pass through the barrier.

In a second class of commercial superconducting devices, specific voltages are applied to make the superconducting material switch rapidly (within a few picoseconds) from the Josephson to the Giaever tunneling current. This allows for analog-to-digital conversions at an ultra-fast rate, particularly important for operating advanced communications systems or for capturing analog signals to be processed and analyzed in a digital computer.

For example, Hypres, Inc., of Elmsford, N.Y., has developed and marketed a workstation that can be used as a high-speed superconductor oscilloscope. It measures voltage changes at rates even faster than occur in gallium-arsenide electronic circuits (for which conventional oscilloscopes are simply too slow). The superconducting component of the oscilloscope consists of fewer than 100 tunnel junctions, comparable to the most primitive integrated-circuit technology. Nevertheless, it is the first commercial application of superconductors in a digital electronic system.

A third and last variant of commercial superconducting devices relies on another aspect of the Josephson effect. When a superconducting tunnel junction is irradiated with a known frequency of microwaves, a voltage develops across the junction. The voltage is proportional to the frequency of the waves, and because this frequency can be made extremely precise, a correspondingly precise voltage can be produced. In 1972 the National Bureau of Standards developed an array of superconducting tunneling junctions to serve as a national voltage standard. And in 1985 the bureau developed a chip consisting of some 2,000 Josephson junctions to produce voltages up to two volts with an accuracy of one part in 100 billion. The chip is now commercially available to designers and manufacturers of high-precision instruments and electronic components.

In certain respects, high-temperature superconductors ought to have a greater immediate impact on these electronic applications than on the large-scale technological systems described above. For example, in most electronic applications the superconducting material is deposited on a silicon chip (or some other material) in the form of a thin-film. Early indications suggest that the new ceramics can be successfully applied in this way. Also, researchers at IBM have achieved high current density in thin-film samples made from these materials. The company has used its ceramic thin-film in a prototype high-temperature SQUID.

However, even if the new materials can be used in electronic systems, their effect on the cost and functioning of present-day devices will be moderate. Consider the SQUID. The extreme sensitivity of su-

PHOTO: BIOMAGNETIC TECHNOLOGIES

Military satellites may some day carry superconducting electronic systems cooled by the low "room temperature" of outer space.

perconducting electronics to magnetic fields degrades as the temperature increases, because the higher the temperature, the greater the "noise" from moving electrons. For applications where a SQUID's ability to detect magnetic fields is already near the limit (magnetoencephalography is one example), it will be necessary to operate at liquid-helium temperatures—whatever the critical temperature of the particular superconductor used.

The superconductor oscilloscope would probably benefit somewhat from the new high-temperature superconducting materials, as operating at liquid-nitrogen temperatures would save on cooling costs. However, the improvement would be marginal, because the superconducting part of the electronics, albeit critical, is only a few percent of the overall cost of the system. And the National Bureau of Standards voltage standard is such a specialized application that any cost savings would have a neglible economic impact.

What about applications not yet commercially viable? One frequent suggestion is to replace all the interconnecting wire in semiconductor electronic devices with superconducting material, generating less heat and increasing circuit speed. However, two main difficulties stand in the way.

First, a superconductor has zero resistance only at direct current (DC), not at alternating current (AC). The back-and-forth movement of the alternating current leads to resistance. And AC is the current at which computers and other electronic devices run.

One way to decrease the resistance is to lower the temperature. The lower the temperature, the more electrons condense into the superconducting state. This means that a superconductor has to be operated at below half its critical temperature. Even those new high-temperature superconductors with critical temperatures in the neighborhood of 100 K must operate at below approximately 50 K to be practically useful.

And even if a superconductor could be found with a transition temperature of 150 K or more, so that it could safely operate at the temperature produced by liquid nitrogen (77 K), the technological benefit would most likely be small. At such low temperatures, copper is an effective connector in silicon devices. Indeed, a superconductor that could improve on copper wire at room temperature would have to have a transition temperature in the neighborhood of 600 K or about 327° Celsius!

Another much-discussed possibility is the use of Josephson junctions to build a much smaller—and therefore much faster—computer. A conventional semiconductor transistor uses a small voltage to act as the "on-off" switch necessary for the binary arithmetic of digital devices. The amount of heat this produces has traditionally been a crucial obstacle to miniaturizing computer components. When a Josephson junction switches to the non-superconducting state, the voltage that occurs is 100 times weaker than that produced by semiconductor transistors, so considerably less heat is generated.

Unfortunately, it is not simply a matter of replacing semiconductor transistors with superconducting Josephson junctions. Totally new concepts in circuit design and computer architecture are necessary before superconducting computers can be built. Josephson junctions are controlled by the application of a small magnetic field provided by a current, while most semiconductors are controlled by applying a voltage. Also, the ability of transistors to function as amplifiers has proved convenient in conventional computer designs—but Josephson junctions do not have this capacity. And once these design challenges are met, still other problems having to do with the reliable manufacture of Josephson junctions will need to be resolved. Whether they use conventional or high-temperature superconductors, superconducting computers are a long way from commercial application.

One highly specialized but important small-scale application where the new materials may make an immediate difference is space electronics, in particular special sensors and detectors used by the Department of Defense. Here, performance rather than cost is the key factor. Cooling a superconductor with liquid nitrogen would mean lighter payloads and, hence, less need for rocket fuel. Systems might also operate much longer with a given amount of coolant. Finally, with appropriate shielding from the sun, it might even be possible to run a high-temperature superconducting electronic system with no coolant whatsoever, leaving refrigeration to the cold "room temperature" of outer space.

The Challenges Ahead

Despite the many challenges on the road to practical superconducting technologies, the recent scientific breakthroughs in the field remain extremely important. They are the prelude to the continuing devel-

Fermilab's Tevatron high-energy accelerator in Batavia, Ill., uses conventional superconducting magnets to bend charged particles around a 4-mile ring.

Physicists have proposed a Superconducting Super Collider that would use 10,000 such magnets in a 53-mile ring.

opments that will make widespread superconductor applications possible.

Before the discovery of high-temperature superconductors, progress in superconductivity was measured by quite small increases in critical temperature, often of less than one degree. Today, there is no reason to believe that the dramatic leaps in critical temperature inaugurated by superconducting ceramics are over. Researchers may find new high-temperature superconducting materials with less severe technical limitations than the ceramics we know today. And if the day ever comes when a superconductor can be reliably manufactured to operate effectively at room temperature, then superconductors will be incorporated in a broad range of everyday household devices—motors, appliances, even children's toys—with a large consumer market.

High-temperature superconductors may also cause us to extensively revise our traditional theories about how superconductivity works. Should it turn out that superconductivity in ceramics involves new physical mechanisms, then these mechanisms could lead to applications never considered before.

The recent discoveries have already reinvigorated superconductivity research. What was once largely the domain of a relatively small group of scientists has become a genuinely multidisciplinary realm. Now physicists, materials scientists, chemists, metallurgists, ceramists, and solid-state electronics engineers are all focusing on superconductivity. The cross-fertilization of these disciplines should contribute to further discoveries of importance to the practical application of superconductors.

Finally, all the attention generated by recent discoveries has led to increased funding for superconductivity research. Venture-capital firms have identified superconductivity as a promising area for investment. And given the potential importance of superconductor technologies to national-security needs, the Defense Department may become a major catalyst of superconductor R&D, much as it did for the fledgling computer industry some 30 years ago.

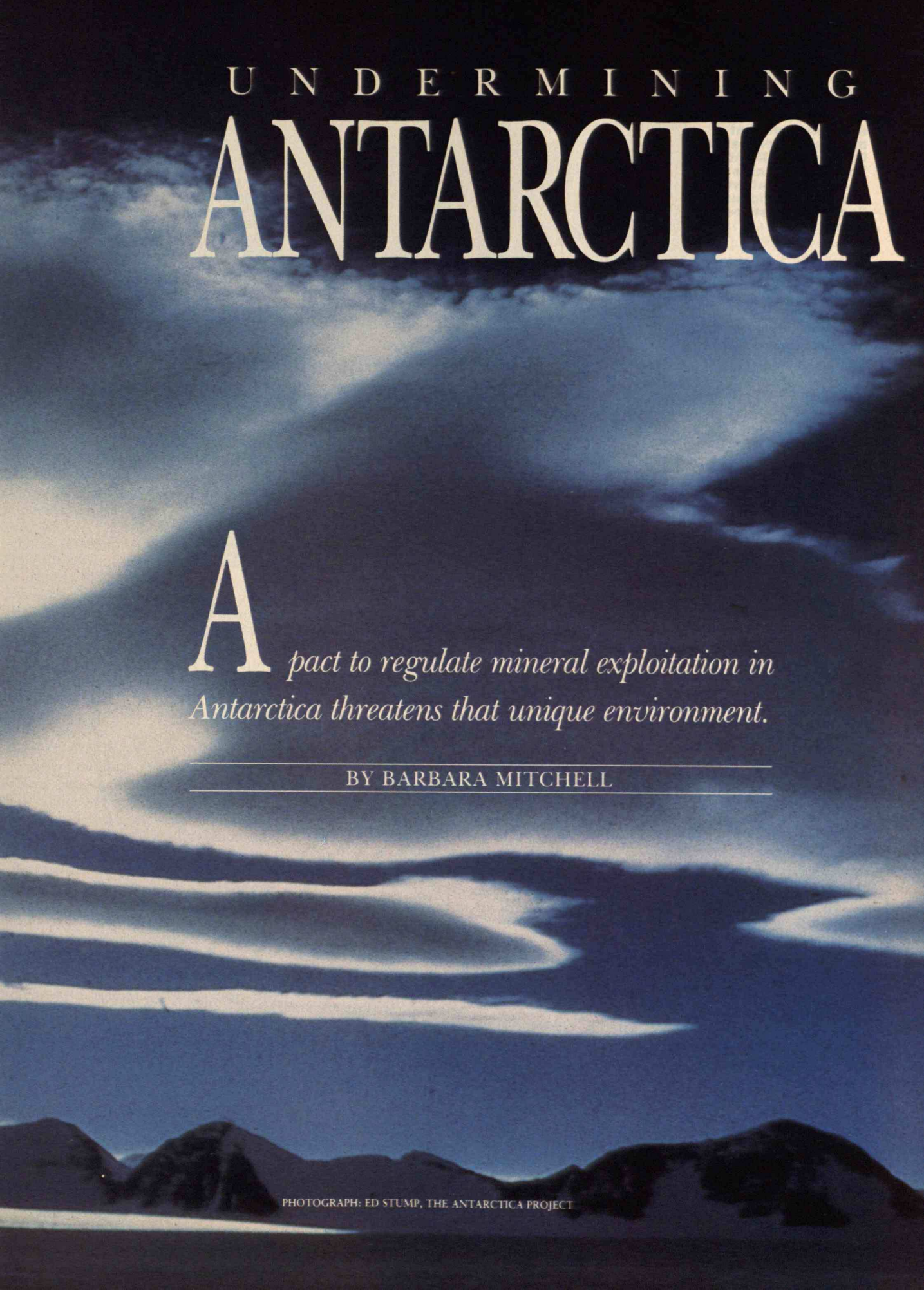
All these indicators suggest that superconductivity has entered a dynamic new phase. But a great deal remains to be done. □

PHOTO: FERMILAB

UNDERMINING ANTARCTICA

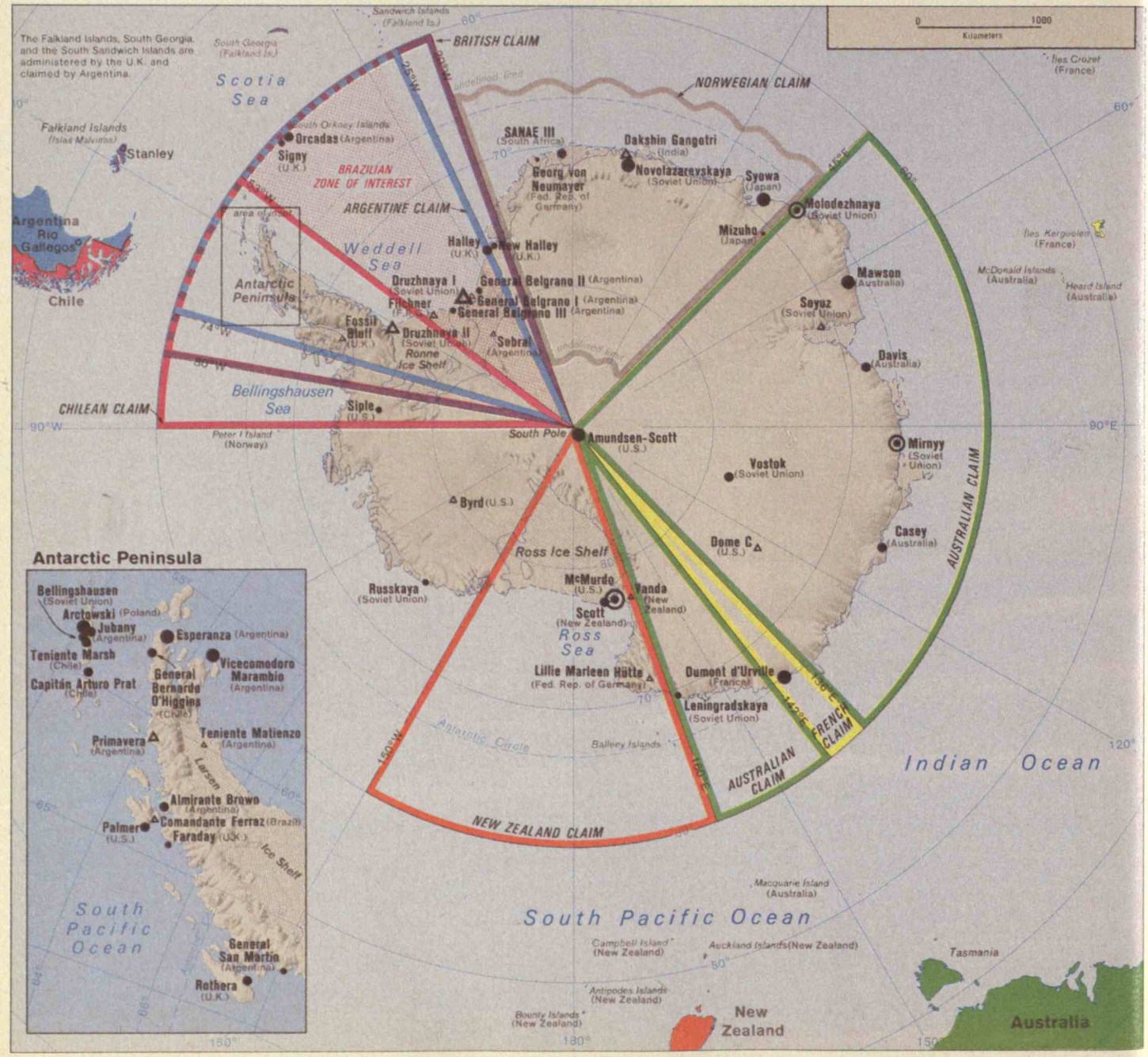
A pact to regulate mineral exploitation in Antarctica threatens that unique environment.

BY BARBARA MITCHELL



PHOTOGRAPH: ED STUMP, THE ANTARCTICA PROJECT

Below: This map shows more than 50 research stations operated by 7 countries that have staked claims to Antarctica, and 8 nations that maintain a general interest there. Right: The U.S. operates the South Pole station. The geographic pole lies near the striped pole.



MAP: U.S. CENTRAL INTELLIGENCE AGENCY; PHOTO: JIM BARNES

At first glance, Antarctica seems an unlikely focal point for a complex political fight. One and a half times the size of the United States, the continent is almost completely covered with ice more than a mile thick. For six months of the year the area is shrouded in darkness.

But Antarctica is not a global footnote. Its seas contain one of the world's richest concentrations of marine life. And the continent and adjacent shelf may harbor quantities of oil, gas, and other minerals.

Many nations want to cash in on these resources. So in 1980 the member countries of the Antarctic Treaty—the agreement that sets the continent aside as a peaceful scientific reserve—signed a pact to regulate the harvesting of fish and other Antarctic life. Now the group, consisting today of 37 nations, is trying to finish a legal framework for exploiting minerals in the region.

This action has not pleased many Third World countries that do not belong to the treaty, such as Malaysia and Nigeria. They believe that they have as much right to be working on the pact as does the United States, Argentina, or Norway. They argue that Antarctica belongs to all of humanity, and that even if they lack the money to drill for oil they should receive some of the profits from exploitation. After extensive deliberations on the issue, the United Nations passed resolutions in 1986 and 1987 calling on the Antarctic Treaty members to stop their negotiations until the entire international community could participate fully in the talks.

But the treaty parties continue to work on the pact. That decision could prove dangerous. In the future, outsider nations that have the means to explore for minerals will have every temptation and excuse to sidestep rules about who can exploit and how. Although these countries could join the pact, at that point they may find it easier to go their own way than to abide with regulations.

Environmental groups also want to stop the work on the minerals pact, or at least delay its implementation. They worry that exploitation will despoil Antarctica—that the environmental safeguards of the pact will be inadequate and that they won't be enforced.

Such concern is more than just a matter of principle. For one thing, Antarctica is of great value to the scientific community. During the time when the sun never sets, astronomers find the south geographic pole excellent for studying solar oscillations, which can provide clues to the sun's interior composition. The vicinity around the pole is one of the few areas on earth not protected by the magnetosphere, so physicists can study low-energy cosmic radiation that can't reach the globe elsewhere. The region's extreme cold and long days and nights provide biologists with special insight into the adaptation of flora and fauna to severe conditions. The area's simple terrestrial ecosystems are ideal for investigating basic ecological processes. For geologists, the area includes some of the world's clearest examples of plate tectonics.

As now drafted, the minerals pact begs the question of who will be responsible if problems occur.

Even more important, Antarctica plays a vital role in global atmospheric and oceanic systems. Its vast frozen crust, which accounts for more than 90 percent of the world's ice, greatly affects weather and sea levels and contains an invaluable record of the earth's climatic history. The continent provides precious information on increases in atmospheric carbon dioxide and global pollutants such as DDT.

In other words, what happens to Antarctica is of vital importance to us all. It is essential, then, that the minerals pact now being devised heed the concerns of the many nations that don't have a say in Antarctica today, and that it does not endanger this precious continent.

Breaking the Ice

Antarctica was not sighted until 1820. Nobody spent the winter there until 1898, and that was by accident, when seawater froze around a Belgian ship. Then exploration, first by dogsled and later by airplane, brought Antarctica closer to the rest of the world. By the mid-1950s seven countries—Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom—had staked claims to parts of the area on the basis of discovery, occupation, geographic connections, or historic rights. (As former colonies of Spain, Argentina and Chile even defended their positions by referring to a 1493 papal decree that granted all lands west of the 46th meridian to Spain.) Each of these "claimants" divided the continent into slices radiating from the South Pole. The British, Chilean, and Argentine titles overlapped, while one portion was not claimed.

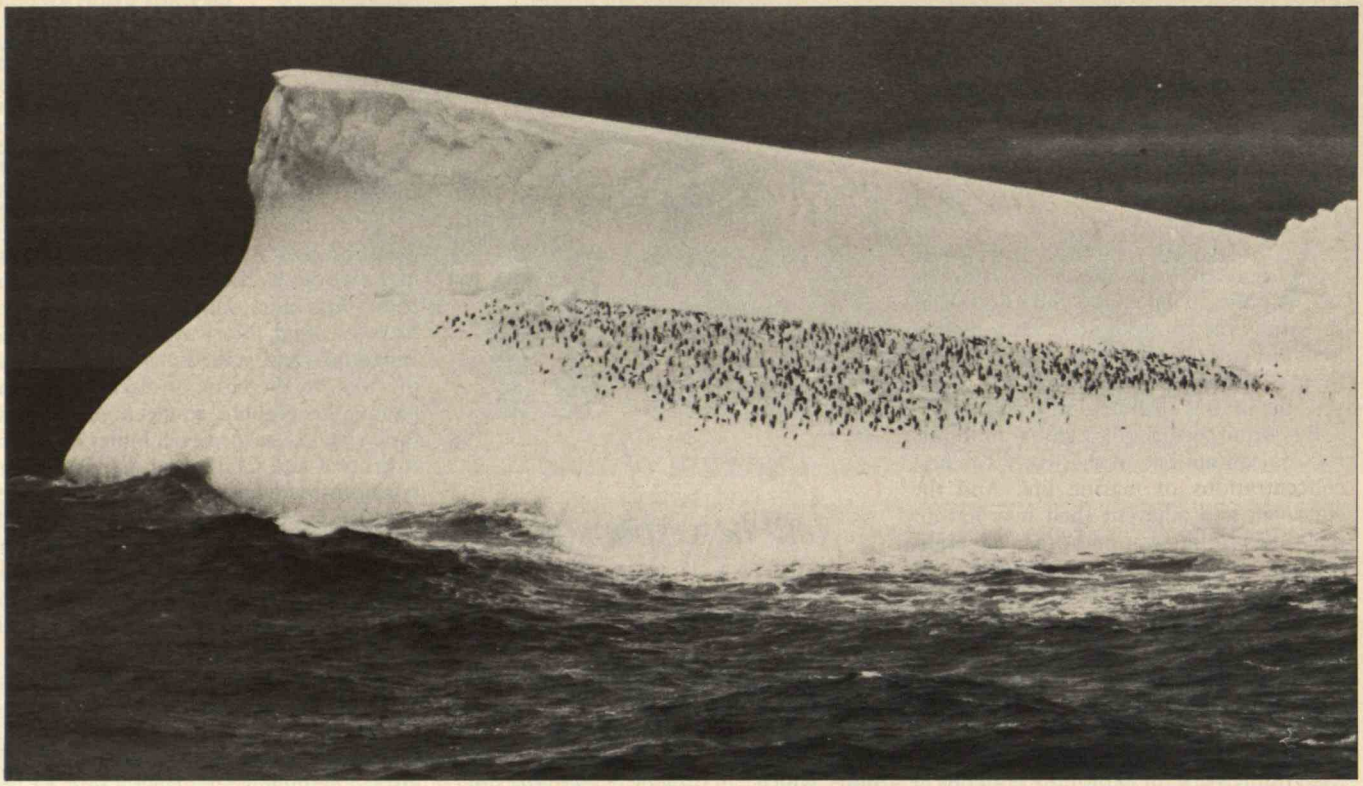
Five other nations—Belgium, Japan, South Africa, the Soviet Union, and the United States—refrained from claiming specific territories. These "nonclaimants" instead maintained a "general interest" in the area, not recognizing the claims. The situation was patently unstable and open to abuse.

Then in 1957-58, the International Geophysical Year, a collective research effort organized under the International Council of Scientific Unions, singled out Antarctica for special scientific study. This prompted the 12 nations interested in the continent to set aside their territorial differences and launch a massive scientific onslaught on the region, establishing 48 research bases. They began to see scientific cooperation as a long-term key to the Antarctic political dilemma. In 1958 the United States invited its 11 partners to the negotiating table in Washington to hammer out guidelines for cooperation in this effort.

The resulting 1959 Antarctic Treaty sets the continent aside as a research preserve where nations freely exchange scientific results and personnel. The treaty bans military activities, nuclear explosions, and the disposal of radioactive waste in the region. It sidesteps the issue of ownership by stating that the sovereignty rights of the interested parties are not affected by the treaty, and that no activities undertaken while the treaty is in force can serve as the basis for new claims or for justifying existing claims. To ensure compliance with

BARBARA MITCHELL, a free-lance writer, examined the implications of resource activity in Antarctica with the International Institute for Environment and Development (IIED) in London and Washington, D.C., between 1975 and 1985. She is the author of Frozen Stakes: The Future of Antarctic Minerals *(IIED: 1983).*

ALL PHOTOS EXCEPT PAGE 57: COURTESY OF THE ANTARCTICA PROJECT



the treaty, observers from each country have the right to inspect any station, installation, and equipment in the region.

All decisions must be made by consensus of an inner circle of treaty members. Although any member of the United Nations may join the agreement, only the 12 original signatories and other states that conduct "substantial scientific research activity" in Antarctica can participate in these deliberations. These members meet every other year to draw up recommendations on matters such as telecommunications and air safety.

A Lukewarm Record

Despite the fact that it pulled together the nations interested in Antarctica, the treaty has problems. Although the provision allowing other nations to join the treaty may seem open, it limits the decision-making club to those countries that can afford to set up scientific operations in Antarctica. (In recent years, India, Brazil, China, Uruguay, Poland, Italy, West Germany, and East Germany have joined this group.) Those nations that do not support research stations may attend the meetings only as observers.

Any impression that the Antarctic Treaty parties have risen above political scrabbling is untrue. Scientific research is the currency of political ambition in Antarctica, with claimants siting their stations in their claimed areas. The United States fights hard to maintain its South Pole station situated at the hub of every claim, while the Soviets ring the continent with their stations.

Moreover, the treaty's record on environmental protection is only fair. The ban on activities other than scientific research was a step in the right direction. And in the 1960s and 1970s the parties adopted safeguards to protect Antarctic wildlife and sites of natural, scientific, or historic interest. For years the scientific stations posed no threat because they were so spartan and few. But today, 18 countries and one independent organization, the environmental group Greenpeace, operate more than 50 stations with more than 3,000 summer employees. The outposts are seriously overcrowding certain areas that provide a home for seals, penguins, and other birds. Peter Wilkinson, the director of the Greenpeace Antarctic expedition, has commented that the rubbish left by the United States and other countries is "like a running sore on the side of Antarctica." And the stations' power generators produce gases, heat, dust, and noise that interfere with scientific study of the area's "pure" environment.

A particular threat to the environment is the way the treaty sidesteps the issue of territorial claims. Since there is no agreement about who owns what, it is hard to pin down which nations are responsible or should take action when environmental troubles arise. For example, in the early 1980s the French started to construct an airfield at Dumont d'Urville, in an area they had claimed in the days before the treaty. In the process of preparing the land for the runway they injured and killed many birds, and destroyed the habitat of many others. The treaty forum never raised the point that the construction seemed to violate codes of conduct agreed to by its members.

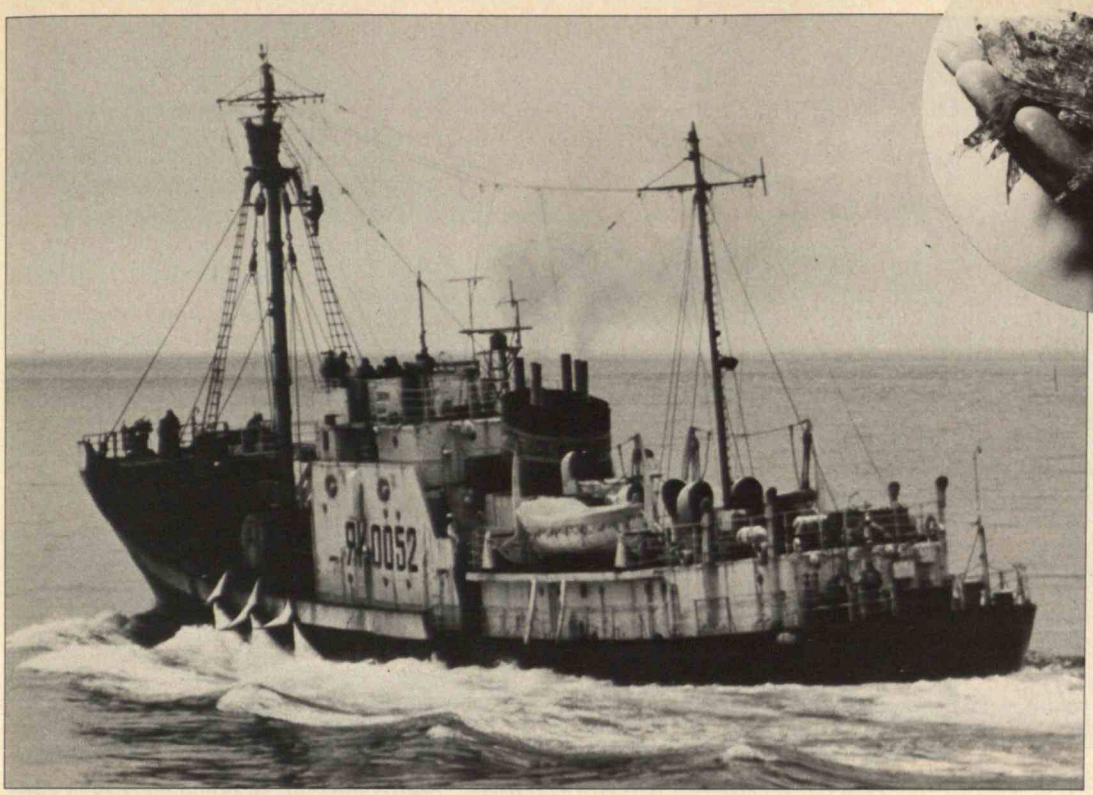
Only after an outcry from Greenpeace and other environmental groups did the French government look into the affair. A specially established French committee echoed the concerns of Greenpeace. In the end, a lack of funds curtailed the project, although there are signs that it will start up again.

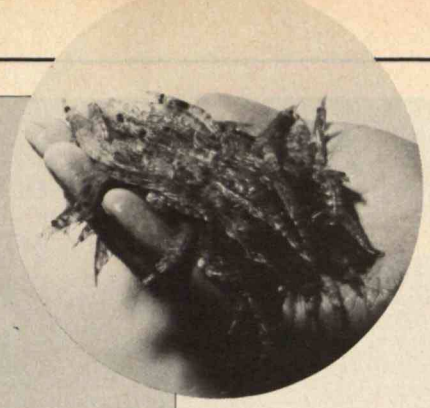
Overall, then, the treaty parties' frequent references to environmental protection need to be treated with a healthy skepticism.

Harvesting Fish and Krill

Some of the problems inherent in the treaty have also shown up in the 1980 Convention on the Conservation of Antarctic Marine Living Resources, which regulates the harvesting of Antarctica's waters. This activity became an issue in the 1970s when the Soviets started fishing in the ocean surrounding the continent. At first they concentrated on Antarctic cod and ice fish, but they soon began hunting for krill, a small shrimplike crustacean. Krill forms dense shoals in the Antarctic summer, and it has the same protein content by weight as beefsteak.

Scientists initially viewed krill as the answer to the world's protein problems, but biologists quickly became alarmed at the





Far left: Despite the continent's desolation, the surrounding ocean is rich with such wildlife as penguins, seals, fish, and whales. Left: A number of nations harvest fish and other species off Antarctica. In the early 1980s Soviet catches included minke whales, as permitted at the time. Above: The Antarctic harvesting pact imposes few effective controls on fishing for krill, a tiny crustacean.

potentially serious consequences of overfishing the species. Krill is very low in the food chain and is the main food for many species of whale, seal, fish, squid, and bird. Concerned that not enough was known about the ecology of krill, scientists rapidly downgraded their safe-yield estimates.

Luckily, the fishing fleets simultaneously ran into practical problems that lessened krill's appeal. The crustacean is hard to process, partly because its shell releases contaminating fluoride if not removed immediately. Antarctica's distance from home ports, its short fishing seasons and harsh weather, and variations in patterns of krill swarms year to year also made the venture difficult. Catches peaked at 500,000 metric tons in the 1981-82 summer season, then fell dramatically.

But the general trend has been upward in recent years. Of course, the amounts vary annually, according to how successful fishing crews are in finding the crustacean. Krill fishing has increased especially as overfishing has depleted stocks of Antarctic cod. At the same time, many of the krill-processing problems have been solved. Fishing boats now carry special peeling machines and operators use fast-cooking and -drying methods to create an animal feed product.

Another species recently harvested is the crabeater seal. In the summer of 1986-87 the Soviet Union killed 4,000 seals in what it called a "scientific harvest." In 1972 the Antarctic Treaty parties agreed to control any future sealhunting in the region; they plan to meet this September to discuss the matter.

The Living Resources Convention imposes few effective controls on such harvesting. The agreement is famous for its sweeping environmental purview and infamous for its lack of teeth to back that up.

The pact applies to all living marine resources south of the Antarctic Convergence—an ocean boundary marked by rapid temperature and salinity changes that lies roughly between 50 and 60 degrees south. The boundary affects climate, marine life, and iceberg drift.

The convention contains an "ecosystem standard"—harvesting is not supposed to decrease a population to levels below those that allow stable replenishment. If populations are depleted, they are supposed to be restored. In addition, signatories must maintain ecological relationships among species and prevent changes in the marine ecosystem that "are not potentially reversible over two or three decades."

Unfortunately, that standard does not provide the basis for a workable pact. Its meaning is ambiguous, it provides no way to verify compliance, and it lacks practical guidelines.

Just as vague are the convention's references to jurisdiction. In fact, conflict between claimants and nonclaimants became the main stumbling block during negotiations to establish the convention. At one point, talks almost crumbled as claimant states refused to abandon their "rights" to control fishing within 200 miles of their claimed shorelines. Ambiguity finally won the day. The convention guarantees the right to exercise "coastal state jurisdiction"—but it does not specify who enjoys this right. And similar to the Antarctic Treaty, the convention purports not to affect any nation's claim to sovereignty.

This inexact position is fine as long as no country complains of encroachments on its claimed waters. But what would happen if one region proved particularly rich, and so many nations fished those waters that the claimant protested or tried to insist on license fees? The convention could not solve the problem, as it has avoided all issues related to sovereignty.

A more immediate problem is that the convention's conservation measures, including catch limits, must be decided by consensus. Unless all the countries agree on limits, each nation can catch any amount it wishes. Even when the parties have settled on a catch limit, any nation may later object to it. And there is no mechanism for allocating how much fish each nation can harvest. Thus, fishing proceeds essentially unregulated. The agreement has not halted the depletion of finfish and is not controlling krill fishing.

A general lack of interest in conservation among the convention parties kept matters static until 1985, when the Australian delegation took the unprecedented step of publicly decrying the adopted measures. It complained that the parties were considering species and fish stocks

PHOTOS: WOLFGANG FISCHER; DOTTE LARSEN

The Antarctic Treaty parties have assumed a great burden in making decisions about the continent.

singly rather than as interdependent members of a community.

Most of the pact's members have blamed the harvesting problems on the Soviet Union, which does not accept the safe-yield estimates of other countries and has refused to agree to catch limits. But the ultimate responsibility belongs to the parties as a whole, whose loose *modus vivendi* allowed the situation to arise.

Matters are finally beginning to take a turn for the better. At last autumn's annual meeting on the harvesting agreement the Soviet Union became more cooperative. The parties also recognized the need for a practical set of management rules and set up a working group to develop them.

Exploring for Minerals

But even if fishing practices improve, the Antarctic environment is by no means out of danger. Exploitation under a soon-to-be-completed minerals pact could pose another threat.

Nations have shown even keener interest in reaping some Antarctic minerals than they have in harvesting fish. The Pensacola mountains near the Weddell Sea may conceal stores of platinum. And since the energy-starved 1970s, nations have explored Antarctica's continental shelves for signs of oil and gas.

Oil has yet to be detected offshore, but geologists have found tantalizing indirect evidence of its presence. Seismic surveys have revealed that sedimentary conditions are right, and in 1985 the German ship *Polarstern* found evidence that rock just beneath the seafloor contained organic material suggestive of petroleum at lower depths. In late 1986 a New Zealand team drilled in the Ross Sea and deep down found a six-foot-thick layer of sand stained by a waxy hydrocarbon residue, indicating that petroleum had existed there in the past.

But nations and oil companies will have to decide whether petroleum exploration in the Antarctic makes economic sense. So far they are in doubt about the near future, partly because of production difficulties they would encounter at the bottom of the world.

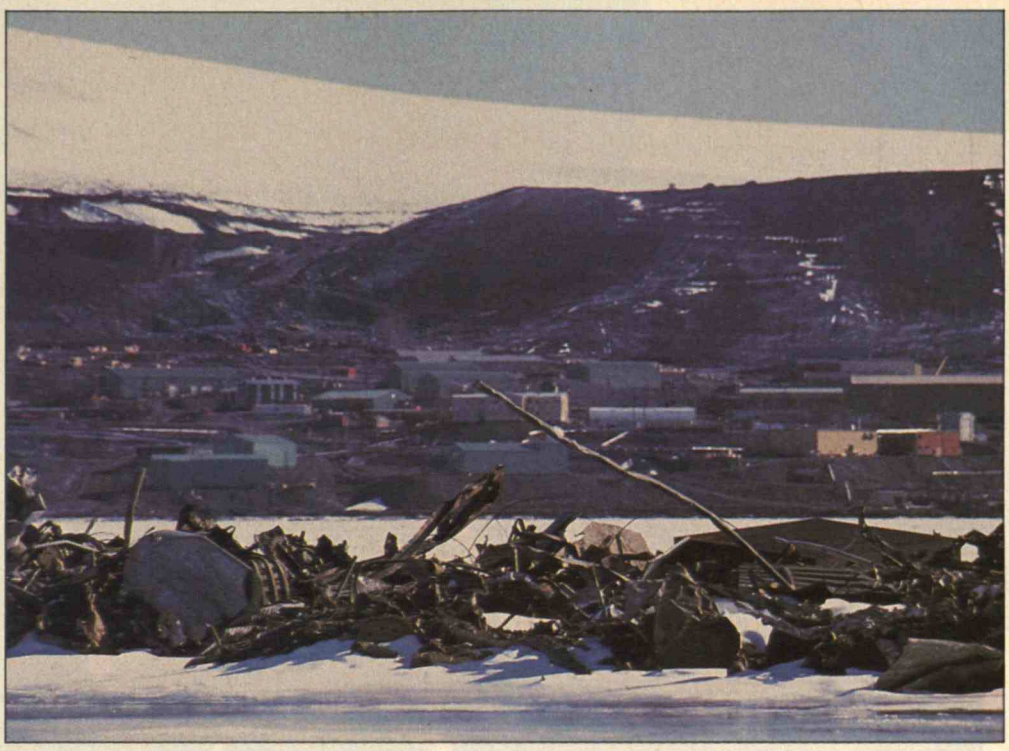
Why couldn't oil exploration teams simply transfer the technology they use in the Arctic? One of the biggest problems is the icebergs that slough off Antarctica's ice shelves—which in winter extend about 1,000 miles past the shore. The icebergs that break off these shelves are much larger than their glacially formed counterparts in the Arctic. When an iceberg is bearing down on an oil-drilling rig in the Arctic, crew members often send out a tugboat to tow it away. If the iceberg is larger than about 100 cubic meters, they disconnect the rig from the well and leave quickly, later returning to reconnect. But about a third of Antarctica's waters have so many large icebergs—many of them a cubic kilometer—that oil-drilling operations would have to flee often.

Furthermore, the deep water surrounding much of Antarctica would make it too costly to install the platforms that sit above production wells. Platforms are used to control the flow of oil, and often to separate it from other constituents rising from the wells. The deeper the water, the larger a platform must be to remain steady. In the Arctic, most platforms sit less than 300 feet above the seafloor. The water off much of Antarctica runs much deeper.

The alternative, which would also be very expensive, would be to use remotely operated production systems. For example, oil companies could set up control valves not on a platform but on the seafloor, as they have done in deep waters elsewhere. Submerged pipelines would carry the petroleum to treatment facilities and tanker terminals. Where these facilities would be located is anybody's guess. They could not be set up on Antarctica's permanent ice cap because the ice is constantly shifting. If they were built on the small ice-free portion of Antarctic land (which presumes that such development could avoid harming wildlife populations and research bases), tanker traffic would still have to avoid icebergs. The best sites might be on other continents or islands, but building pipelines these distances would be extremely costly.

Moreover, the Antarctic region's remoteness from supplies and markets would mean higher product costs. And the world is currently enjoying an oil glut, and uncertainties remain about which countries can claim mineral rights in Antarctica. As a result, most experts doubt that exploiting any oil found in the region would be profitable for years to come.

But nations may still want to hedge against future uncertainties by locating new petroleum supplies. And they may use oil exploration and production to further



Environmental problems now pose a threat to a pristine continent. Far left: In late 1983 the French dynamited several islands near their Dumond d'Urville station to construct an airplane runway. Above: The project's blasting killed these Adelie penguin chicks, shown shoveled into a pile. Right: Trash accumulated near the U.S. McMurdo Bay station last year. Such refuse used to be dumped in the ocean. The U.S. says this policy has changed.

their political ambitions in Antarctica. Several countries have already taken such a stance in the archipelago of Svalbard, 250 miles north of the Norwegian mainland. Before 1925, Svalbard belonged to no country. Then a treaty was drawn up to provide for a diluted form of Norwegian sovereignty that gave other contracting states formal rights of access. Partly to consolidate these rights, Norway, Great Britain, the Netherlands, Sweden, the Soviet Union, and the United States sent companies to investigate the area and mine ore deposits so small they would have been ignored elsewhere in the Arctic. Conceivably, some countries may follow this policy in Antarctica, subsidizing petroleum exploitation there.

But drilling for oil would put the environment at great risk. The harsh local conditions would increase the likelihood of oil spills and hinder remedial measures. And because of the extreme cold, an oil spill would probably break down slowly. In the worst-case scenario, major spills could decrease the reflectivity of large amounts of sea ice, melting it, with disastrous effects worldwide. However, after eight years of work on a minerals pact, the treaty parties have yet to agree on foolproof arrangements that will prevent such abuses and establish responsibility in the case of environmental problems.

The Minerals Pact: Only a Framework

Although the minerals pact is unfinished, its broad features seem clear. Intended to regulate exploration and production on Antarctica's landmass and continental shelves, it will be a framework, not a detailed mining code.

The pact will include the same fuzzy provisions about jurisdiction as the Living Resources Convention, so that claimants' and nonclaimants' positions will again be "protected." Once more, this begs the question of who is responsible where, and who is to enforce responsibility.

As the minerals pact now stands, the Antarctic Treaty decision-making parties plus nations that actively exploit resources in the area will oversee what happens. These states will set up a commission to develop the pact's guiding principles. Committees representing specific areas of the region will use these principles to draw up requirements for mineral activity in their territories. Each committee will consider applications for mineral exploitation and act as a forum for negotiating matters such as taxation and enforcement in the case of violations.

The regulatory committees are designed to bypass the standoff between claimants and nonclaimants. Each committee will probably consist of 10 parties to the minerals pact, including nations with territorial claims in the area, and, for balance, several nonclaimant states. The parties drawing up the minerals pact generally agree that each committee will include representatives of the United States and the Soviet Union. And they appear to accept representation from developing countries that will be decision-making members of the commission—Brazil, Argentina, Chile, India, China, and Uruguay.

The pact will incorporate an environmental standard: no mineral activity is to take place until there is enough information to ensure that it will not significantly harm the Antarctic or related ecosystems, animal and plant populations, climate, or weather patterns. And activities must not risk despoiling areas of biological, scientific, historic, or aesthetic significance.

A Familiar Vagueness

Unfortunately, the minerals pact is unlikely to offer Antarctica the environmental protection it deserves. If past performance is any indication, the parties will probably not shoulder the responsibility of holding one another to the environmental standard. Environmental groups are alarmed that the ongoing uncertainty about claimant and nonclaimant positions, for example, will lead to a familiar vagueness about enforcement and complaint procedures.

In addition, many Third World countries want a say in the negotiations. The two recent U.N. resolutions calling for world participation in the minerals pact have turned up the heat on this long-standing argument. Once again Third World nations are pressing the concept that certain areas and resources should be the common heritage of all humanity. This idea forms the centerpiece of the Law of the Sea Convention, ratified by 32 countries. Other nations, including the United States and Great Britain, have opposed details in that convention and have refused to endorse it. Nevertheless, many less developed nations are holding fast to the agreement.

In the case of the minerals pact, these

PHOTOS: GREENPEACE

nations sense that time is running out. If they do not challenge the negotiations now, the Antarctic Treaty parties will be able to claim international acceptance.

Under this kind of pressure, the members have recently made changes to the Antarctic Treaty's operation. The 17 nations that have signed the treaty but have no Antarctic research stations are now allowed to attend meetings, although they cannot participate in decisions. And the number of treaty members with decision-making power has increased to the point that they now represent more than 80 percent of the world's population.

But the treaty remains an exclusive arrangement. The entrance fee for full membership—setting up a research station—is still too steep for many countries. The negotiation process remains secretive; talks are held behind closed doors and documents are not released except by leaks. And the parties lobbied hard to prevent the U.N. from discussing Antarctica. What's more, nongovernmental expeditions—past and present—have reported a lack of cooperation from treaty members. For instance, Greenpeace has complained that New Zealanders and Americans have denied the environmental group weather information and helicopter landing rights at research stations.

A Realistic Solution

There are no simple solutions to the political controversies surrounding the minerals pact. But some alternatives exist. Greenpeace, for example, has proposed an outright ban on mineral exploitation, preferring to declare Antarctica a world park. The concept sounds similar to the agreement the treaty members hammered out for Antarctica in 1959, but adds the idea of complete protection for the region's wildlife and wilderness. Limited scientific activity could take place, with scientists of all nations working in cooperation. And the area would be free of nuclear and other weapons and all military activities.

At the moment, however, only environmental organizations support the idea of a world park. Since treaty members are unlikely ever to accept that proposal, a more realistic option would be to improve the minerals pact so that it protects the Antarctic environment and responds to the qualms of nations that don't belong to the treaty.

To protect the environment, the parties

Accidents from oil drilling could harm Antarctica. An oil spill would probably be slow to break down and difficult to clean up, and would threaten Antarctica's wildlife. Above: Nations drafting the Antarctic minerals pact should ensure that it protects the continent and allows vital international research to continue.

should detail what information will be required to judge whether exploration or production will cause harm. Environmental impact assessments should be open to public comment. An area should be opened to exploration only when all the pact's commission members are satisfied that it is safe.

In drawing up detailed regulations on such matters as safety, water and air pollution, inspection rights, and liability in the case of damage, the committee members should clearly reflect the agreement's basic environmental standard. These rules will become the contract terms for exploiters and form the basis for prosecuting any violations. All the rules, especially those on liability, must be in place before activities occur. Such rules should be open to public review and revision in light of new information and improved technology. The parties should clearly specify the conditions under which revised rules would apply to previously approved operations.

The treaty parties would also do well to allow the treaty members who today can only observe meetings to comment on the minerals pact. In addition, the parties should actively involve the U.N. in their meetings. These steps could begin to ease the concern that only select parties—most of whom are developed nations—have a say.

The greater the number of nations involved, the easier it will be to defend the minerals pact and the Antarctic environment against encroachment. In the future, some countries could attempt to exploit Antarctic resources without being bound to any restrictions.

It will be more difficult to respond to the idea that all nations should profit from Antarctic mineral exploitation. But the treaty parties could share a small proportion of any mining revenues with the international community, or set up joint ventures in Antarctica with Third World nations.

The treaty parties have assumed a great burden in making decisions about Antarctica. Although they have done much to promote cooperation and protect particular sites in the region, so far they have not fully demonstrated that they deserve the jurisdiction they claim. Only by making the minerals pact responsive to environmental concerns and to the views of the other nations of the world will they prove they merit this responsibility. □

INSET PHOTO: INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

Trading Trade Secrets

BY ERIC VON HIPPEL

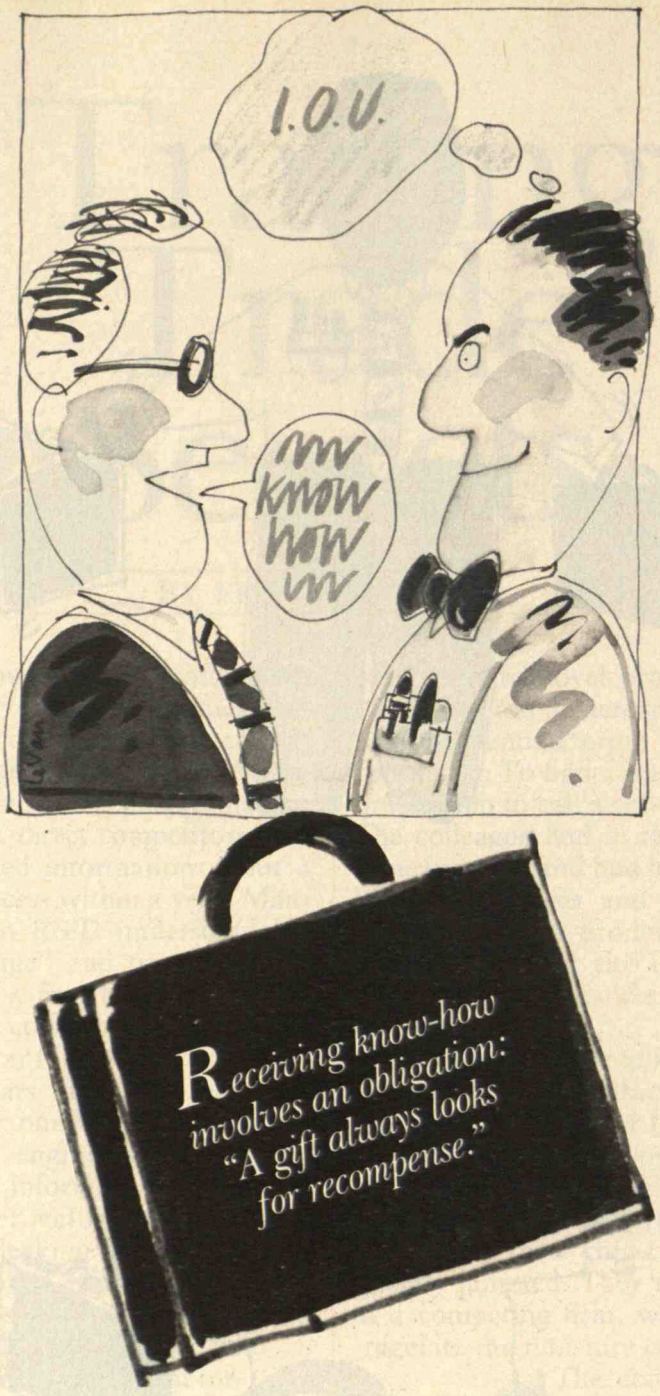
In studying innovation, I have often been struck by how rapidly a technical advance made by one firm spreads to others in the same field. Indeed, Edwin Mansfield of the University of Pennsylvania has recently shown that direct competitors generally secure detailed information about a new product or process within a year. Managers who invest in R&D understandably view this as "leakage" and try to stop it. After all, how can a firm benefit from expensive R&D if its competitor quickly gets the same information for free?

But it now appears that these managers are looking at only one-half of a two-way transaction. Often engineers are actually trading proprietary information—or "trade secrets"—for other valuable know-how rather than simply leaking it. Perhaps managers have overlooked this difference because the two sides of such trades rarely occur simultaneously. An engineer who asks a colleague from another firm for information incurs an obligation that may not have to be repaid for months.

Consider an example of know-how trading in aerospace. New high-performance materials often require novel production techniques. An engineer at an aerospace firm was having trouble manufacturing a part from a new composite. To find a solution, it seemed natural to him to call a colleague at a rival firm. The colleague had in fact worked with the same material and had learned how to refine his mold designs and regulate processing temperatures to produce better parts. He willingly passed the information along, knowing that he could expect a similar favor one day.

A second example of know-how trading is in waferboard manufacturing. Waferboard, sometimes substituted for plywood in construction, is made of wood cut into waferlike chips that are glued and pressed into sheets. Engineers at one waferboard manufacturer found that their chip-cutting machine frequently jammed. They turned to colleagues at a competing firm, who advised them to regulate the moisture content of the wood. The colleagues were happy to share their knowledge, confident that the favor would be returned.

Know-how trading appears to be linked to informal networks among engineers who



have common interests. Such networks are formed at conferences and other occasions where engineers have a chance to meet, judge one another's abilities and areas of expertise, and develop contacts. When these engineers later encounter technical difficulties, they may call an appropriate contact, possibly one who works for a direct competitor.

The engineer contacted for help usually makes two judgments. First, would revealing the information significantly hurt his firm's competitive position? (For example, does the caller want details regarding a product that has not yet been released?) If so, the engineer will not reveal the information. Second, is the caller in a position to furnish useful expertise at some other time? If so, the engineer who has been contacted will be more inclined to help.

The informal help can be quite extensive, such as running a special simulation on a computer. While no explicit accounting is kept, the engineers who receive help appear to realize that they have an obligation to reciprocate. The code of behavior is similar to that described by the anthropologist Marcel Mauss in *The Gift: Forms and Functions of Exchange in Archaic Societies:* "A gift always looks for recompense."

Like managers, when I first observed engineers helping competitors with technical information, I couldn't understand why. It didn't seem to make economic sense. But once I saw this curious behavior as a trading system, I realized that it could be profitable to the firms involved and, moreover, could be an industry-wide mechanism for sharing technical know-how—and many other types of information.

Trading Among Steel Minimill Firms

Informal know-how trading appears to be practiced in many industries, though often without management's sanction or even awareness. So far, I have found it common in aerospace, waferboard manufacturing, and steel minimill firms. To give a better picture, let me describe what my student Richard Orr and I found happening in steel minimills.

The term "minimill" is not precisely defined, and is becoming less so as such plants grow in size and complexity. Early minimills were relatively small, with 50,000 to 150,000 tons of steel per year capacity. Today, however, some individual plants approach 1 million tons annual capacity.

The chief distinction between minimills and "integrated" steel plants is that minimills do not produce steel from iron ore. Rather, they begin with steel scrap and melt it in an electric arc furnace. After the chemistry of the molten metal is adjusted, it is cast continuously and rolled into steel shapes. Modern facilities and relatively low labor, capital, and materials costs have enabled U.S. steel minimill firms to drive U.S.integrated producers essentially out of the market for many commodity products such as wire, simple angles, and the steel reinforcing bars used in concrete.

To get a good overview of the industry, Orr and I interviewed personnel about know-how trading in

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ILLUSTRATIONS: SUSAN LEVAN

11 of the 40-odd U.S. minimill firms. These included the four largest: Chaparral (with a capacity of 1.4 million tons per year), Florida Steel (1.6 million tons), North Star (2.3 million tons), and Nucor (2 million tons), as well as six randomly selected firms (Bayou Steel, Cascade Steel Rolling Mills, Charter Electric Melting, Kentucky Electric Steel, Marathon Steel, and Raritan River Steel). In addition, I studied Quanex after some interviewees told me that its trading behavior was different from the rest of the industry.

We began by determining that all the minimills we studied do develop at least some proprietary know-how that they can choose to hide or trade. Nucor and Chaparral undertake major development efforts to improve their production processes. For example, Nucor is investing millions to develop a new type of continuous-casting equipment that can produce much thinner and wider steel shapes. This new process could be of tremendous value to the minimill industry, perhaps doubling the size of its potential market.

The other firms we studied made smaller but still significant improvements in process equipment and techniques. For example, one firm was experimenting with a flatter furnace roof to provide increased clearance and allow faster loading. Others have developed modified mill rollers that can produce better or different steel shapes. While each such improvement may have only a small impact, the collective effect of many can be great. For example, one U.S minimill claims a 98 percent "yield"—good quality output—of steel tubing, while a French firm using the same basic equipment obtains only a 75 percent yield. The U.S. firm attributes the difference to its engineers' know-how.

Technical personnel at all firms except Quanex reported that they routinely trade proprietary know-how with other minimill firms—sometimes with direct rivals. So informal know-how trading appears to be a nearly universal practice in this industry. Top management is aware of it and does not try to control it beyond providing general guidelines, such as prohibiting personnel from discussing particularly sensitive projects.

All the personnel we interviewed emphasized that they were not giving know-how away but were consciously trading information whose value they recognized. An engineer at Bayou Steel told us, "How much is exchanged depends on what the other guy knows—[the trade] must be reciprocal." A manager at Chaparral said, "If they don't let us in [to their plant], we won't let them in [to ours]."

Information trading can go far beyond an arm's-length exchange of data at conferences. Sometimes firms train operating employees of competitors at no charge, or send personnel to help competitors set up unfamiliar equipment. Traders do not appear to explicitly count the precise value of what is given or received. But they do strive to keep an informal balance, much as neighbors do when inviting each other to dinner.

When Does Know-How Trading Pay?

Quanex is the only minimill we found with a policy of not trading know-how. I have some doubt as to

whether this policy benefits the company, and even whether it is rigorously observed. But it should be a reminder that know-how trading is not necessarily present in all firms in an industry, in all industries, or under all conditions in any industry. In fact, it appears that know-how trading pays only under certain conditions.

Consider a simple model in which a firm's potential profit from know-how consists of two parts. A firm receives "normal profit" from using a unit of know-how even if its trading partner also has it and can use it. But if a firm does not trade the know-how, it retains exclusive use and reaps an additional "monopoly profit."

Suppose two firms each start out with one trade secret, and both secrets have identical values of normal and of monopoly profit. (Although an obvious simplification, this can fairly represent the cumulative average of many transactions.) If the two firms trade know-how, each loses the monopoly profit from its own unit of know-how but gains one unit of normal profit by getting access to a second unit of know-how. This pays off when the normal profit for these units is greater than the monopoly profit. On the other hand, if the monopoly profit is greater, the players benefit by not trading the unit.

The model (described in further detail in my recent book, *The Sources of Innovation*) appears to fit reality well. To gain a feeling for its plausibility, consider some examples in which the monopoly profit value of a given piece of know-how changes over time and trading behavior responds accordingly.

In the petroleum industry, geologists working for competing companies report that they often trade seismic data. This information can be valuable in determining whether there is oil in a specific area, but withholding it usually offers no competitive advantage. If refused the data, the competitor can simply lease equipment, get permits, and generate identical data. However, when acreage comes up for bidding, competing firms may not have enough time to generate the necessary data independently. The competitive value of the information then rises and geologists stop trading it.

A similar situation occurs in the aerospace industry when a competition for an important government contract approaches. During this period there may not be enough time for a competitor to produce some piece of know-how that could make the difference between winning and losing. The monopoly value of that know-how consequently rises, and engineers report that they then stop trading it. After the contract is awarded, the competitive value of the same piece of know-how drops, and trading resumes.

The conditions under which the model predicts that know-how trading will pay seem to be common in industry. For example, trading safety-related know-how makes sense because it typically affords a firm no competitive advantage. Thus, chemical companies trade know-how on reducing production of dioxin, an unwanted toxic by-product. No firm has an interest in denying such information to rivals, since the whole industry suffers if any company produces dioxin.

It also makes sense to trade important know-how that cannot be kept exclusive for long—information that cannot be protected effectively by patent and can be readily reinvented, though at some expense, once the need is recognized. The examples of know-how trading in waferboard production and aerospace illustrate the point. Although the information was useful, denying it to a competing firm would make little difference in the long run. The firm could struggle along until it managed to reinvent what it needed.

Trading this sort of know-how is comparable to the industrial practice of sharing spare parts for production machinery. Denying parts to a competitor would not affect the firm significantly because it could eventually get what it needed from a supplier. But if competitors refused to provide one another with spares, all would have increased downtime or have to pay more to stock spares. This would be a net loss for everyone compared with a policy of greater informal cooperation.

Collective R&D

Know-how trading among technical personnel can be seen as a novel type of cooperative R&D. Of course, firms can also cooperate on R&D in other ways. Agreements among companies to perform R&D collectively, as a consortium of computer and semiconductor firms is doing through the Microelectronics and Computer Technology Corp. (MCC), have recently gained attention. In addition, licensing or selling proprietary information such as patented inventions has long been common. But under many circumstances know-how trading may function better than either of these better-known alternatives.

Although agreements to perform cooperative R&D can allow a number of firms to create a body of new technical knowledge that they could not afford to develop individually, such agreements have limitations. Since the participants pool personnel and relevant knowledge, firms with the best in-house R&D may be reluctant to join: they would have the most to lose and the least to gain. Major U.S. firms

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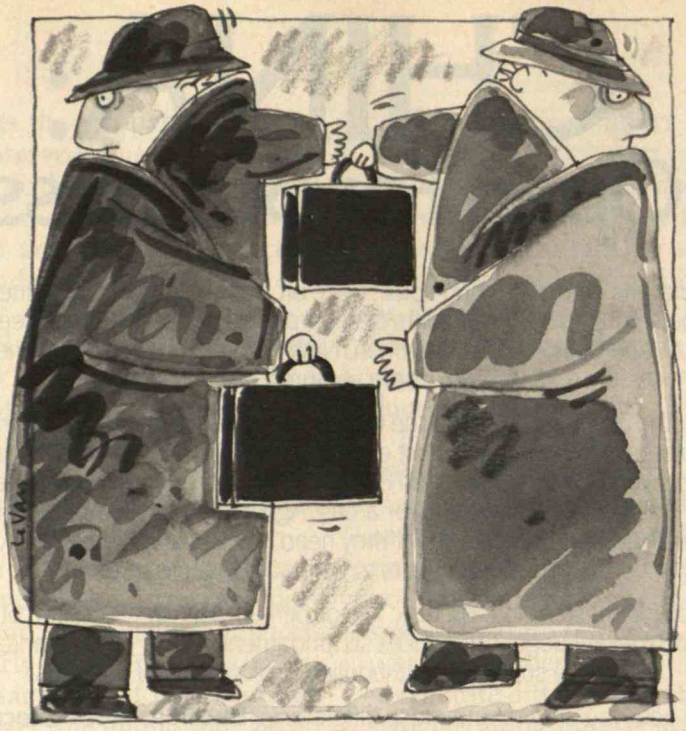


including IBM, Texas Instruments, and Intel decided to stay out of MCC.

Another limitation of cooperative R&D agreements is that they involve substantial uncertainty. Firms cannot confidently predict the value of the research or be sure of receiving all the results. These are best transferred through the employees participating in the research. Given the U.S. tradition of frequent job changes, firms run a risk of losing the benefits of their investment by losing the employees.

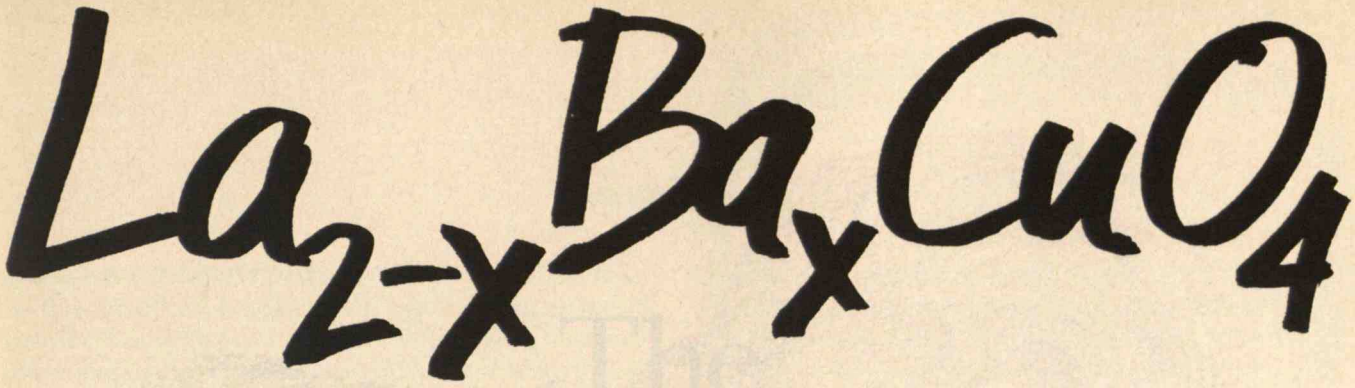
Both know-how trading and agreements to license or sell technical information involve less uncertainty: the information exists, so its value is better known. The drawback of licensing and sale agreements lies in their relatively high transaction costs. Agreeing on the amount to be paid for the information and how it will be protected requires the time of managers, engineers, and lawyers. Formal sale or licensing is likely to work best when a piece of know-how has a value far above these transaction costs. For example, chemical firms may turn to licensing to convey proprietary information on an important new process.

In know-how trading, transaction costs are low because individual, knowledgeable engineers make decisions whether to trade without seeking bureaucratic approvals. Though informal, each engineer's assessment of the value of trades can be quite accurate. An information seeker quickly ascertains the quality of the advice by attempting to apply it. An information provider can test the inquirer's future value as an information source by the nature and subtlety of the questions. Also, though any particular judgment of the value of a trade may be incorrect, the cumulative value of many small transactions probably balances out.

Informal know-how trading will be the most effective form of cooperative R&D when an individual company finds it worthwhile to develop a piece of know-how, but the know-how is not valuable enough to justify an explicit negotiation to sell or license. Since technical progress frequently consists of many incremental advances, this is often the case. For example, in *The Sources of Efficiency: A Study of Du Pont Rayon Plants,* Samuel Hollander found that it was primarily the cumulative effect of many small improvements that allowed Du Pont to cut the costs of rayon production by nearly two-thirds over four decades.

Know-how trading does pose risks. Those who do the trading might not have the firm's interests in mind, and even if they do, they might lack all the information needed to decide whether to make a trade. If such problems exist, managers probably should not try to solve them by prohibiting know-how trading. This may merely drive it underground—I have discovered trading in firms with policies against "revealing" information. Instead, managers might bring this practice into the open to examine ways to reduce the risks and gain the benefits that know-how trading can bring.

In doing so, managers may discover what we are now finding. Though first identified among engineers, know-how trading is not restricted to them or to the exchange of technical data. For example, a computer sales manager in Brazil trades information with his competitor on how to deal with the local bureaucracy but would never provide a tip about important pending sales. Trading appears to be a fundamental human strategy for diffusing valuable know-how in many different fields. □



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The Cheshire Cat's Grin:

INNOVATION AND REGIONAL DEVELOPMENT IN ENGLAND

SINCE 1981, when London's *Financial Times* proclaimed that "science parks are suddenly all the rage," British government and universities have invested over £150 million in developing high-technology innovation centers. These beautifully landscaped areas, modeled after California's Stanford Industrial Park, are the most visible symbol of U.K. efforts to promote high-technology development.

Such initiatives—common in Western Europe and the United States—assume there is a recipe for high-tech growth. The secret, this thinking goes, is to combine a familiar list of resources: a research university, an industrial park, venture capital, public support for new technologies, and a desirable social environment.

The assumption is that once these prerequisites are assembled, innovation and economic success will follow. Like a soufflé that exceeds the size of its ingredients, any region endowed with the proper mix of institutions and resources will be able to grow the next Silicon Valley.

The idea that ample supplies of venture capital, engineers, research

BY ANNALEE SAXENIAN

The difficulties of Cambridge companies suggest that traditional recipes for high-tech development are misleading.

ILLUSTRATIONS: ROGER JONES

funding, and an appropriate environment—without social constraints like unions—will produce innovative enterprises and regional development is a variation on the free-market economic model in which perfectly competitive firms and unimpeded flows of money, labor, and information maximize economic efficiency and wealth. This conceptual framework has led economists like George Gilder to glorify California's Silicon Valley as a testimony to the resilience of entrepreneurial capitalism and Prime Minister Margaret Thatcher to view Cambridge, England, as a breeding ground for Britain's "enterprise culture."

This approach, which separates the economic marketplace from its social and political environment, is flawed. By focusing solely on a region's local attributes, the high-tech growth recipe overlooks the ways that institutions shape economic outcomes. The result has produced misguided policy and a misinterpretation of the Cambridge experience. Despite apparent success, entrepreneurs there have failed to create commercially viable firms or to construct a regional environment conducive to new technology-based enterprises.

Cambridge: High-Tech Hope. . .

Cambridge should be a prime candidate for buoyant high-tech growth. It is richly endowed with the elements identified in standard recipes:

☐ The University of Cambridge is a world-class institution, renowned for technical excellence in physics, computers, and electronics. Its Trinity College holds more Nobel prizes than most nations.

☐ In 1970, Trinity established Cambridge Science Park, which has boasted high occupancy rates ever since.

☐ Cambridge is the home of several venture-capital firms, and ample local financing is available for technology companies.

☐ The region offers a highly prestigious address and a desirable living environment. It is within commuting distance of London and enjoys easy access to Heathrow and Gatwick airports.

☐ No unions blemish the area's white-collar, high-tech image.

☐ The British government offers extensive support for new technology. Department of Trade and Industry funding for innovation, science, and technology has increased more than fivefold since 1978.

Not only is Cambridge blessed with the prescribed ingredients for success, but the often elusive process of firm formation and entrepreneurship is healthy there. Cambridge has the largest concentration of high-tech start-ups in Europe. During the early 1980s, an average of 30 technology-based enterprises formed each year, and by 1985 the area was home to over 400 high-tech companies. Local activists dubbed the experience the "Cambridge phenomenon."

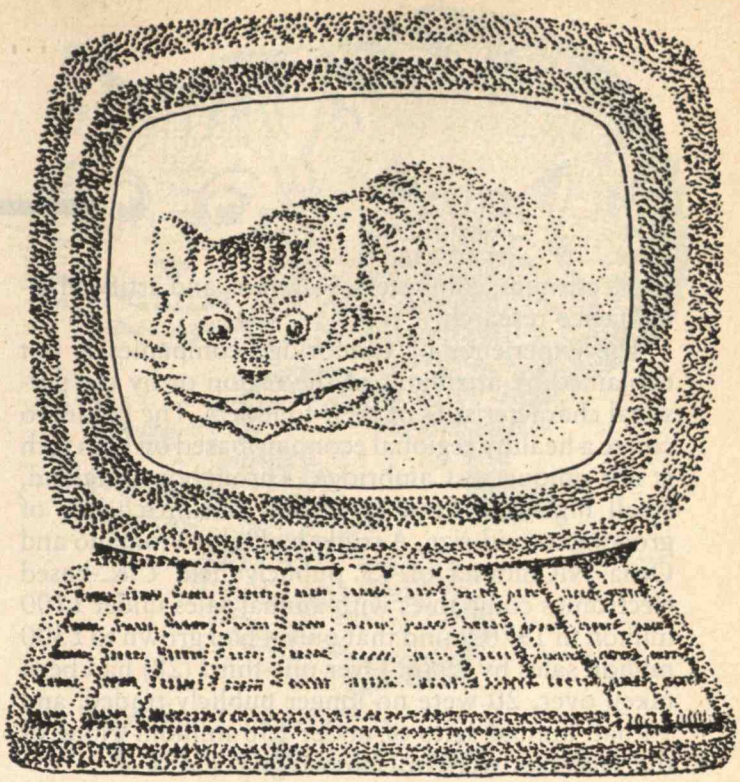
The immediate origins of the phenomenon date from the mid-1960s and the Labor government's commitment to "reforge Britain in the white heat of the scientific revolution." Prime Minister Harold Wilson's programs brought millions of pounds of funding to Cambridge University labs. Millions more poured into the region after a government-funded national computer-aided design (CAD) facility opened in 1969.

The first of three waves of technology-based company formation in Cambridge began in the late 1960s with a handful of spin-offs from the university labs. These included such firms as Applied Research of Cambridge (ARC), a CAD company specializing in architectural and building graphics; Laser Scan, which makes hardware for computerized mapping systems; and Cambridge Scanning (CamScan), a producer of high-quality, customized scanning electron microscopes.

The fate of these firms was typical. ARC grew but struggled with financial instability for over a decade before it was bought by its U.S. distributor. Laser Scan survived by building up business with the Ministry of Defence (MoD) before it, too, was taken over by its distributor. CamScan remains independent but has failed to expand.

Some of the most successful and well-known companies in Cambridge date from a second wave, beginning in the late 1970s. Acorn Computers and Sinclair Computers are two of the better-known products of a microcomputer boom in Cambridge that included ten such companies. When support from the government for the CAD center began to waver, several of its star engineers struck out on their own, creating Cambridge Interactive Systems (CIS) and Shape Data—the best known of several CAD

ANNALEE SAXENIAN is a graduate student in the M.I.T. Political Science Department. She has written extensively on the urban and political development of Silicon Valley.



firms that emerged in this second period.

The third and largest start-up wave began in the early 1980s. This deserves to be called the "Thatcher boom," as it has been fueled by the dramatic increase in venture capital since 1979. New Tory programs like the Business Expansion Scheme, which provides tax relief to investors in small companies, ensure that more funding for new businesses is available in Britain than anywhere else in Europe.

While the Cambridge region had some 40 technology-based firms in 1978, by 1983 it had almost 250, and by 1985 over 400. Despite little or no industrial experience, Cambridge University graduates or faculty started most of these companies, which are primarily engaged in electronics, computer hardware and software, instrumentation, scientific consulting, and R&D.

. . . or High-Tech Hype?

Upon close examination, however, the promise of Cambridge and its scores of high-tech businesses is as elusive as the Cheshire cat. The overwhelming majority of the firms that have been started since the late 1960s remains very small. In 1984, almost 30 percent of the companies in Cambridge had fewer than six employees and 75 percent had fewer than thirty. In the same year, close to half the region's firms had sales of less than £350,000.

Small is not necessarily bad, but employment figures in Cambridge hardly suggest fast-paced regional progress. Local high-tech firms employed approximately 16,500 workers in 1986, and the majority of these jobs existed prior to the onset of the "high-tech boom." At most, the hundreds of firms started during the past decade have created 6,000 jobs. Industrial employment in Cambridge remains concentrated in a few large, older firms.

In addition, takeovers of the most technically promising companies are increasing. The region's leading CAD companies—CIS, ARC, and Shape Data—all faced financial crises and were acquired by their U.S. distributors in the early 1980s. In 1985, Olivetti rescued Acorn Computers from collapse and Amstrad took over a failing Sinclair Computers.

Many local entrepreneurs now predict the end of the Cambridge boom, and others refer to it as the Cambridge hype. Cambridge remains, of course, a prestige address and it offers a desirable environment and lifestyle for engineers: it will no doubt survive as a location for R&D operations of international corporations and as the home for scientific consulting and professional service activities. However, recent trends point to a slower growth rate for indigenous high-tech start-ups. Only a handful of the firms formed in the past two decades have over 50 employees or sales over £10 million.

The promise of Cambridge and its scores of high-tech businesses is as elusive as the Cheshire cat.

World-Class Technology, Second-Class Firms

Why this lackluster performance? Cambridge entrepreneurs do not lack scientific brilliance, nor do their products lack technical sophistication. Indeed, many of the entrepreneurs are at the leading edge of mi-

croelectronics, computers, software, and artificial intelligence research.

The experience of Cambridge companies is not explained by attributes of the region or by the personal characteristics of their founders. The failure to create a healthy regional economy based on high tech is not unique to Cambridge. Throughout England, small high-tech firms have only a slim chance of growing to mid-size. A study by Philip Modiano and Orna NiChionna of 73 publicly held U.K.-based electronics companies with annual sales under £100 million in 1970 found that only 4 had grown to £300 million sales by 1986. Over one-third (28) had been taken over, 20 were no longer publicly traded, and 13 had annual sales of under £50 million. None of the successes were in Cambridge.

The difficulties of Cambridge companies are rooted in the British economic and political context. New enterprises face a dearth of markets, managers, and manufacturing experience.

Britain's protracted decline as an industrial economy dates at least from the 1890s. By the end of the Second World War, most sectors of British manufacturing—from coal, steel, and shipbuilding to machine tools, aircraft, and radar—lagged seriously behind their European and U.S. competitors. Ongoing decline since then has left Britain with an atrophied industrial base and a lower standard of living. In 1983 British manufacturing showed a trade deficit for the first time since the Industrial Revolution.

This places a severe burden on new high-tech firms. The largest civilian markets for electronics—automotive, data processing, and instrumentation—are all in crisis. Even relatively healthy British enterprises have been slow to invest in technological change. As a result, Britain today is commonly estimated to represent less than 5 percent of the world high-tech market.

Another major source of demand for high-tech products is the military. Yet decades of national policy have closed this outlet to new technology-based enterprises. The preponderance of military spending—like other major government programs for high-tech industry—has gone to large, well-established firms.

In the absence of a home market, the entrepreneur with an idea for a high-tech product must look abroad. This disadvantages new enterprises in several ways. Because high-tech firms often serve markets that they help to create, they must maintain close personal contact with potential customers, especially in the initial stages of product definition and design. This demands overseas relationships that few engineers have or can make on their own.

Moreover, a successful export strategy requires marketing skills and knowledge of foreign markets. As with product development, marketing places a high premium on international contacts that the typical Cambridge entrepreneur lacks.

Finally, distribution is critical to selling technology-based consumer or producer goods in foreign markets. Lacking the resources, experience, or relationships to establish foreign distribution and service networks, most successful Cambridge companies link up with an international distributor. This strategy, however, further reduces contact with customers and their changing needs. It is not surprising that many Cambridge firms are eventually bought by their distributors.

In short, the need to enter foreign markets from the onset places unusual demands on new high-tech enterprises in Britain. Firms from other nations with small domestic markets face similar problems. Yet the successful ones typically benefit from access to a robust national industrial and skill base, as in Germany, or from supportive relationships with large firms and the state, as in Japan.

Markets and Managers

The most common complaint of Cambridge entrepreneurs is the shortage of top-quality international marketing expertise. Silicon Valley entrepreneurs seldom have international marketing experience either, but they can hire marketers from other U.S. firms with international operations. Such know-how is hard to find in Britain. This derives in part from low status—one Cambridge-based consultant described the "immense lack of respect for marketing in Britain"—and in part from the small number of British firms competing in foreign markets. It is especially rare to find engineers or scientists in marketing, precisely what a technology-based firm needs most.

Cambridge firms report related problems in their attempts to find product-engineering, manufacturing, and general managerial expertise. To take just two cases: Inmos, the semiconductor company, has first-rate design talent but is hamstrung by limited production capabilities, and Acorn Computers has

devised microprocessor chips as elegant and powerful as anything in Silicon Valley but has failed to incorporate them into commercially viable systems.

These difficulties can be traced to the British education system—historically both exclusive and narrow. Britain was very late to create technical universities and continues to have a pressing scarcity of skilled technical and managerial personnel. Engineering was not introduced and accepted as a legitimate educational field until half a century after the rest of Europe, and its status and caliber remain low. Most British managers are both undereducated and poorly trained compared with their international counterparts.

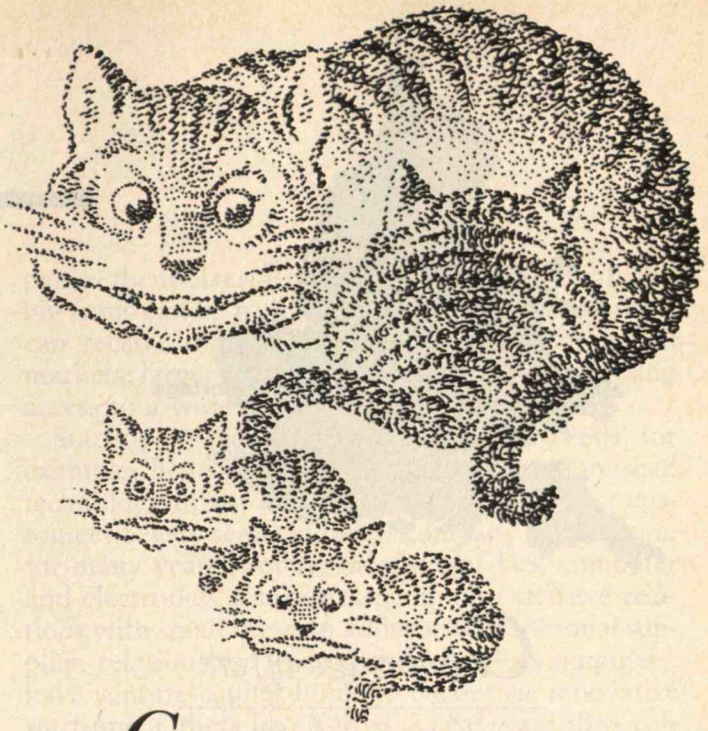
In addition, British engineers and managers are reluctant to leave an established company. As a result, the pool of expertise that start-ups have to draw upon is even more limited than it would be otherwise. Contrast this with Silicon Valley, where managerial turnover is ubiquitous.

While supplying skilled engineers and managers is primarily the responsibility of a country's education system, many significant contributions to industry grow out of accumulated production experience. A nation's technical infrastructure is embodied both in its engineers, researchers, and managers and in the network of firms that produce manufacturing equipment and products. It is the product of many incremental insights and ongoing interchange.

Despite its world-class science base, Britain's lost manufacturing capacity has undermined its ability to maintain a healthy technical infrastructure. New technology-based enterprises rely heavily on foreign firms for the most sophisticated inputs. Like shortages of engineers and managers, the deficiencies of the technical infrastructure cripple British firms as they enter world markets.

The Politics of British High Tech

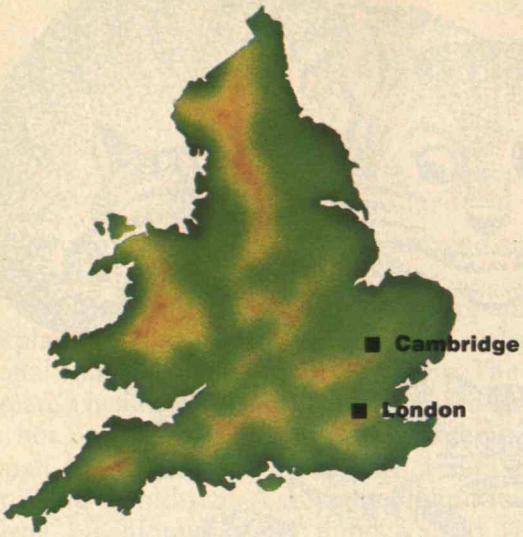
On the surface, current British policy appears to be precisely what regions like Cambridge need: explicit state commitment to small-firm growth and high-tech industry. The Tory government has articulated a vision of a thriving private-enterprise economy, as is evident in its policies to promote firm formation and innovation and in the acclaim accorded to such entrepreneurs as Clive Sinclair. It is also evident in the growing portion of the Department of Trade and Industry (DTI) budget devoted to microelectronics and other advanced technologies.



Cozy relations with state agencies ensure that the lion's share of government spending enriches a small circle of large electronics firms.

However, the overall impact of British post-war politics and policy has been to further undermine new technology enterprises by constraining the resources available to them. Cozy relations between state agencies and large electronics companies characterize virtually all advanced-technology sectors in Britain. These relations ensure that the lion's share of government spending enriches a small circle of firms.

Even before Thatcher came to power, the dominance of large firms in Britain's electronics industry had been consolidated. In the 1960s, creating "national champions" was at the center of the Labor government's efforts to bring advanced technology to domestic industry. The Industrial Reconstruction Corporation (IRC), established in 1966, facilitated mergers so British companies could achieve the scale



Cambridge offers high-tech enterprises a highly prestigious address within easy commuting distance of London.

needed to compete in world markets.

One early product of IRC's enthusiasm was International Computers Ltd. (ICL), Britain's sole mainframe-computer maker—merged from International Computers and Tabulators Ltd. and English Electric Computers. And the merger of the three leading British electrical-engineering firms in 1969 created the General Electric Company (GEC), now the largest manufacturing employer in the nation and the chief beneficiary of government electronics spending.

State policy not only created large firms, it has also ensured their survival, primarily through the activities of the Ministry of Defence. A 1983 House of Lords Report on Engineering Research and Development thus describes "the creation of a circle of large firms who have prospered through MoD contracts and have become almost totally dependent on them." The report goes on to argue that these firms "form a closed community, which continues to receive the main contracts." The MoD is the biggest customer of the U.K. electronics industry, and through R&D funding it is a major, and probably the largest, source of technology. Not surprisingly, electronic capital equipment—for such uses as avionics, radar, advanced weaponry, and telecommunications—is the only sector of the British electronics industry with a positive balance of trade.

Consider the evolution of Britain's semiconductor industry. MoD's Components, Valve and Devices (CVD) division is the major source of R&D funds, exceeding even the industry's own R&D spending.

During the 1970s, over 80 percent of all government support for the semiconductor industry in Britain went to five firms—Ferranti, GEC, STL/ITT, Phillips, and Plessey. Ferranti alone received half of the total. The MoD was, in turn, the primary market for these firms, typically accounting for at least one-third of total sales. Close associations between the companies, the CVD, and government research establishments gave rise to the so-called CVD club. Both those within this select group and outsiders have acknowledged how difficult it is to join this exclusive circle of favored clients.

This pattern is repeated in all sectors of military electronics. Over 60 percent of all defense contracts go to 10 large companies. GEC, Plessey, Ferranti, Thorn EMI, and Racal each received over £100 million in MoD contracts in 1984. And the military has represented a major portion of firm sales as well: in 1986 it accounted for 31 percent of GEC sales, 38 percent for Plessey, 37 percent for Racal, 60 percent for Ferranti, and 9 percent for Thorn EMI.

Relations between the large electronics firms and British Telecom, the government-owned telephone company, parallel those with MoD. The same tight circle of technology enterprises dominates production of telecommunications equipment. In 1985, for example, GEC and Plessey alone supplied 80 percent of the U.K. market for electronic components and approximately 50 percent of the telecommunications-equipment market.

Even new government programs to promote innovation and technology industry continue to benefit the same group of established firms. Ken Guy of the Science Policy Research Unit at the University of Sussex recently reviewed the Thatcher administration's showpiece program for collaborative industry-university research in information technology—the Alvey Program. He concluded that it has "simply replicated and reinforced the existing patterns by

MAP: GARDINER MORSE

concentrating projects in the large firm sector." Furthermore, despite Thatcher's rhetorical commitment to high-tech growth, total DTI support for innovation, science, and technology programs—including the Alvey Program, the Support for Innovation Scheme, and programs to promote robotics, microelectronics, fiber optics, CAD manufacturing, and flexible manufacturing systems—amounted to less than one-tenth of the defense electronics and ordnance budget for 1983/84.

British policy has thus created a small number of national champions and then nurtured them with guaranteed markets. This state of affairs contrasts with that in Japan, for example, where despite a protected domestic market firms are forced to compete vigorously with each other. Similarly, in the rest of Europe, civilian national champions must compete in world markets.

The British experience also contrasts with that of the United States, where early government programs in space and military R&D supported fledgling firms in Silicon Valley and helped the civilian electronics industry achieve research and production superiority. Even today, a strong anti-trust tradition underlies Small Business Administration policies to ensure that small firms get some U.S. government contracts.

An Enterprise Culture?

Cozy relations between large firms and the state hinder the development of Britain's small high-tech enterprises in other ways. In the critical area of the supply of talented managers and engineers, state policy gives big firms the advantage. Excluding the small civilian electronics firms from government procurement and R&D expenditures limits their access to skilled labor. Sir Robin Nicholson, Thatcher's chief science advisor until 1986, testified to the House of Lords that "in some areas the Ministry of Defence is so dominant—for example, in electronics and in some of the computer areas—that there are not the people to do the research in the civil area or in the scientific area." In *Lloyds Bank Review,* Mary Kaldor, Margaret Sharp, and William Walker suggest that the military drain on skilled labor, particularly in electronics, has been a major factor inhibiting the expansion of high-tech industries in Britain.

The dominance of large firms also removes a potential source of support for Britain's new technology-based enterprises: the large electronics companies themselves. Relationships between small and big firms can be fruitful for all involved. Small firms can receive market information as well as actual markets; larger companies can acquire flexibility and access to a wide range of technological inputs.

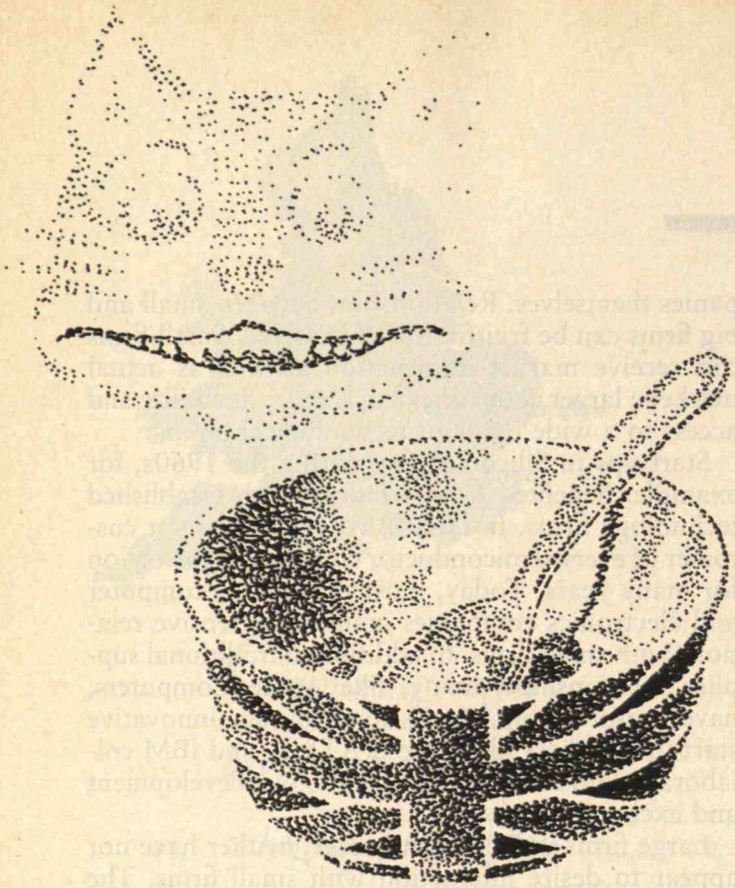
Start-ups in Silicon Valley during the 1960s, for example, benefited from relations with established technology firms. In fact, IBM was the largest customer of every semiconductor company in the region for many years. Today, most major U.S. computer and electronics companies maintain extensive relations with small firms. In addition to traditional supplier relationships, many, like Apple Computers, have venture-capital funds to encourage innovative start-ups. Others like Xerox, AT&T, and IBM collaborate with small firms in technology development and exchange projects.

Large firms in Britain, however, neither have nor appear to desire interaction with small firms. The insularity and inflexibility of big British electronics companies derives from their history of privileged relations with the state. Operating in protected markets, these enterprises are multi-product corporations, organized both individually and through industry associations to ensure the continuing flow of contracts rather than to compete in world markets. In fact, managers of major British companies repeatedly express aversion to small firms. In the words of one Cambridge consultant, "The big firms are, at best, blind or patronizing to small firms."

Not surprisingly, Britain's large electronics companies make limited use of subcontractors. They perform most activities internally: GEC makes everything from chips to missile guidance systems to large-scale electronic equipment. The founders of Qudos, a Cambridge company specializing in leading-edge, application-specific integrated circuits, report on their efforts to sell to large British firms: "We tried every bloody GEC, Ferranti, and Plessey plant that there is. We crawled on our hands and knees and still got nothing—not even a bloody sausage." Their claim that Qudos electron-beam technology is superior to anything in the big firms is supported by Olivetti's subsequent decision to invest in the company and by success outside Britain.

Relationships, Not Recipes

What does this mean for the scores of new start-ups in Cambridge? Representatives of both fledgling



Creating a dynamic high-tech region is not a matter of combining ingredients. It requires building institutions and relationships that support innovation.

firms and established companies in the region confirm that the two have nothing to do with each other. Managers at the big firms report that they see little of value in the small firms around them. The entrepreneurs describe failed attempts to sell to the big firms, and speak with distaste of their inflexibility, technological backwardness, and cultural stuffiness. Andy Hopper, a highly respected and experienced Cambridge entrepreneur, says that subcontracting to small companies in the region is virtually nonexistent: "I don't know anyone who has gotten these contracts, and I don't know anyone who knows anyone who has gotten one."

Deprived of support from the state or the big firms, these entrepreneurs might gain assistance from their financiers. However, venture capital in Britain, while abundant, is very different from that in the United States. The U.S. venture-capital industry has grown in regions like Silicon Valley and Route 128 in Massachusetts from a base of successful high-tech entrepreneurs. These individuals intervene actively in the firms they support, providing networks of industry contacts and years of firsthand experience.

The British venture-capital industry, by contrast, is an artificial creation of recent tax laws. According to Matthew Bullock, director of corporate finance at Barclay's Bank, most British venture-capital financiers are totally inexperienced with technology-based companies. Bullock claims that while 120 venture capitalists in Britain finance high-tech start-ups, only six truly know the businesses they invest in. Most are primarily interested in tax advantages; they supply money, not ideas, guidance, industry contacts, or resources.

Observers of Cambridge often cite social networks among local entrepreneurs as a sign of the region's growing potential. However, tenants of the Cambridge Science Park complain repeatedly that there is no interaction—social or technical—among firms there. Efforts to create forums for information sharing and cooperation in the region have produced disappointing results. And a recent study by Cambridge-based consultants Segal Quince & Partners reports minimal economic links among local firms.

This absence is critical. With little to integrate economic activity, the result is a disarticulated collection of small enterprises and services. While successes may emerge, the regional environment does not support innovation and high-tech growth.

Compare this with Silicon Valley, where a configuration of local institutions and relationships is central to the region's ability to grow and remain innovative. The interfirm mobility of personnel, extensive supplier relationships, collaborative research and product development, well-developed venture-capital networks, and a multitude of forums for technical interchange and risk-sharing ensure that resources and technology diffuse rapidly to new enterprises in the region. It is these relationships between the individuals, firms, and institutions in the region that matter—not their simple presence.

The Lessons of Cambridge

The trials of Paul Johnson, now third-time entrepreneur, illustrate the difficulties small high-tech enterprises confront in Britain today. Johnson founded a Cambridge-based electronics company in 1980 that failed relatively quickly. He then started a home-computer company that succeeded briefly before collapsing in 1985. He has since learned a lesson about doing business in Britain. His latest company, Array Consultants, designs customized integrated circuits. He is selling an engineering service now, and his products are manufactured elsewhere.

Johnson's experience is evidence that attitudes towards enterprise and industry are changing in this historically anti-industrial nation. But faced with a decimated manufacturing base, corresponding shortages of engineering, manufacturing, and marketing expertise, and minimal support from the state and large firms, high-tech entrepreneurs have learned to avoid production in favor of design and consulting.

In other words, Cambridge high-tech entrepreneurs are constrained by the national environment. No set of local policies will overcome the limitations of British markets and politics by itself. Nor will increased national funding of high-tech industry necessarily ensure increased competitiveness. Given current political relationships between established firms and the state, more centralized spending programs are likely to just reinforce the status quo.

Reconstructing Britain's skill and technology base is a long-term undertaking that requires political vision, will, and support. The necessary elements would include broad education and training initiatives and decentralized programs to spread resources, diffuse technology, and promote collaboration among firms rather than high-visibility projects that continue to concentrate resources.

The Cambridge experience suggests that policymakers cannot simply choose to grow the next Silicon Valley. There is no set of local inputs that can be assembled piecemeal to ensure regional success. The high-tech growth recipe, with its vision of autonomous firms and free flows of capital, labor, and technology obscures the social nature of innovation and economic change. Creating a dynamic high-tech region is not a matter of combining ingredients. It is one of building institutions and relationships—both locally and nationally—that support the development of innovative enterprises. □

Brain Waves, and A New Health-Care System

Brain Waves

The Social Brain
by Michael Gazzaniga
Basic Books, $17.95

Reviewed by R.K. Dismukes

Scientists have long known that the brain's hemispheres specialize in performing some mental functions. The left hemisphere seems to dominate in reading, writing, and producing and understanding speech, as well as in verbal learning and memory. The right hemisphere seems to dominate for tasks involving shapes and faces, spatial orientation, color, emotion, and some aspects of music. Yet scientists continue to debate what this apparent division of labor implies for the organization of mental functions.

Some propose that the left hemisphere specializes in logical, analytical processes while the right hemisphere synthesizes information into holistic perceptions. It is difficult to prove or disprove assertions so broadly cast. Yet the notion of hemispheric specialization has captured the public's imagination and been extrapolated well beyond the limits of the scientific data. The initial hypothesis has become a dichotomy between rational and intuitive, deductive and creative, even Western versus Eastern thought. People talk of being left-brain or right-brain individuals, entrepreneurs market training programs that purport to develop the right brain, and educators propose changes in school curricula to give equal emphasis to the two hemispheres.

In *The Social Brain,* Michael Gazzaniga debunks popular notions of left-brain versus right-brain function and presents his own theoretical perspective on how the brain is organized. Gazzaniga is a pioneer in using "split-brain" patients to study brain function. Since 1940 a number of patients with severe epileptic seizures uncontrollable by medication have undergone an operation to cut the massive tracts of nerve fibers linking the brain's left and right hemispheres. This procedure greatly reduces the effect of a seizure by preventing the epileptic discharge from spreading over the entire brain. Amazingly, the operation has little obvious effect aside from controlling patients' seizures. Still, careful research has uncovered subtle but startling changes in the patients' behavioral responses that challenge our notions of the conscious unity of mental life.

To study such patients, scientists present information to only one side of the subject's visual field—so that the information is perceived by only one hemisphere. Researchers have found that if the right hemisphere is shown a picture of, say, an apple, the subject will vehemently deny having seen anything. And indeed, the left hemisphere, which is normally the seat for language, has seen nothing. Yet the subject can correctly choose an apple from a set of pictures.

Researchers may even give information to subjects' right hemisphere that causes them to take some action or feel some emotion. For example, scientists might flash a repulsive picture, causing the subject to turn away. One might assume that patients would be terribly confused to find their bodies doing things apparently unbidden. In fact, when questioned about the action, subjects deftly invent plausible though incorrect explanations. Yet curiously, Gazzaniga never tells us how these patients feel when making up these explanations. Are they aware of confabulating, or are the explanations self-convincing?

Gazzaniga criticizes other scientists' interpretation of split-brain studies, arguing that the right hemisphere is superior merely for processing tactile information difficult to verbalize, not for perceptual integration or holistic thinking. He sees the brain as a confederation of hundreds or even thousands of mental modules that can act on their own, remember events, and feel emotions. In his view the left hemisphere contains modules specialized for language and inference. This inference system interprets what goes on both inside and outside the brain—weaving a story to connect the actions of the other modules, and working with the language system to create a sense of consciousness and an illusion of free will.

Although Gazzaniga's model is intriguing, it is largely speculative. Some aspects are more plausible than others. Split-brain studies do suggest two modular systems capable of emotion, memory, and control of the body. The brain is also known to contain many other functional modules. The most concrete evidence comes from the visual system, where scientists have identified 20 or more different regions that perform discrete tasks underlying perception. However, unlike those that Gazzaniga proposes, these modules are not thought to possess emotion or volition but to function more like mechanical filters or processers.

Some sort of interpretive system must create a coherent view of the input from diverse modules working at several levels in the brain. For example, our expectations greatly influence what we think we see, particularly if the visual scene is ambiguous or incomplete.

But this is a far cry from saying that an interpreter provides explanations for the mysterious behavior of its own body under the control of autonomous modules. An interpreter in a split-brain patient may be forced into this role because it is isolated from normal routes of information. Yet Gazzaniga presents no evidence that normal subjects, with massive communication between their brain hemispheres, do not integrate modular functions.

Explaining Freud and Social Programs

It's hard to be sure exactly what Gazzaniga's model of the brain is; he scatters bits and pieces throughout the book and never fleshes out his ideas. It doesn't help that he organizes the slim volume as a chronology of his career and roving intellectual interests, although this gives the science a personal flavor. Gazzaniga also meanders into numerous anecdotal tangents and provides unnecessary detail on some points while omitting essential information on others.

ILLUSTRATIONS: FRED LYNCH

Some 27 million Americans have no health insurance—up 50 percent in the last 10 years.

The author does suggest intriguing implications of his model. For example, he argues that "co-conscious but nonverbal mental modules" provide a modern, mechanistic explanation of the unconscious processes posited by Freud. But Gazzaniga does not elaborate on this view. Instead he spends most of this chapter describing experiments suggesting that our conscious system does not have access to all the information influencing our behavior.

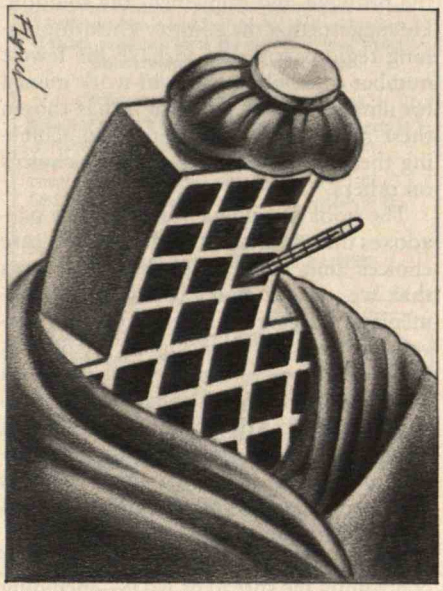
Gazzaniga also argues that his model of brain function accounts for racial prejudice and religious beliefs. He asserts that prejudice arises largely from the invention by the left brain of explanations for life's events. Apparently—and this is not spelled out—the left brain mistakenly infers that untoward events are caused by social groups different from one's own. Similarly, the author sees religion, which he apparently equates with superstition, as resulting from the left brain's attempts to explain natural phenomena such as the seasons.

How does this hypothesis deepen our understanding of social and religious belief? Are not philosophy and science also concerned with inventing explanations for how things work? Gazzaniga's model does not tell us what determines whether individuals seek magical or rational explanations.

He goes even further afield in the last chapter, where he focuses on social programs. He tells us that janitors are paid less than physicists and that social-welfare programs fail because of the way the brain is organized, yet he never states the link explicitly. He argues that social programs are based on an erroneous belief—which he does not specify—about how humans behave. He clearly feels his model provides a better explanation of human behavior.

Social programs certainly do have problems, but Gazzaniga's characterization is at the level one might encounter in a barroom discussion. The connection between social problems and brain science is so tenuous one could as well plump up an argument that his model implies the opposite conclusion.

It is not clear whether Gazzaniga intends us to take this undisciplined foray seriously. His commentary on social issues might be interpreted as the casual speculation we all engage in with friends—one that allows us to see how one scientist thinks about everyday affairs. If taken seriously, his opinions undermine the view of many neuroscientists that their approach provides a more rigorous and powerful understanding of human behavior than other scholarly disciplines.



R.K. DISMUKES, a neuroscientist, is director of life sciences at the Air Force Office of Scientific Research based in Washington, D.C.

Dividing Up Health-Care Dollars

America's Health in the Balance
by Howard H. Hiatt
Harper and Row, $18.95

Reviewed by Sandra Tanenbaum

Howard Hiatt opens his critique of American health care with some familiar observations: the United States spends more per capita than any other nation on health care; we have a larger per capita number of physicians; medicine as practiced at our best hospitals is the best in the world. Still, we rank seventeenth among nations in infant mortality, and life expectancy in 15 countries is equal to or better than our own. The number of Americans without any kind of health insurance—37 million—has grown 50 percent in the last 10 years.

In *America's Health in the Balance: Choice or Chance,* Hiatt uses these statistics to preface a call for health planning. He argues that rationing of health care may be inevitable, but that planning would minimize waste and force society to act on explicit values when deciding who would have access to what care. To ensure "choice over chance," Hiatt would set up regional planning authorities to control the spending of health-care dollars. Everyone in a region would be eligible for benefits, but the authority would serve as the conduit for all private and public health-care funds and set the terms on which they would be available to providers. A percentage of each region's funds would go toward the research that Hiatt posits as crucial to the planning process.

Hiatt is right to remind us that so many Americans lack health insurance, and to be "particularly anxious to reach those who are so callous as to accept the prospect of two-class medicine in America." And he has threaded compassionate case histories through his call for structural change. But his contention that the problems of America's health-care system derive from the triumph of chance over choice is a fundamental weakness. The problems he describes do not arise from a lack of choice in our health-care system, but rather from pursuit of material gain, and from the conflicting choices that result from the different meanings people attach to illness and health.

One example is the problem of prefrontal lobotomy, which fell out of favor after becoming commonplace earlier in the century. Hiatt cites lobotomy as an example of the need to evaluate the efficacy of new technologies. But lobotomy earned the man who invented it a Nobel Prize in 1949—surely a form of peer review. More to the point, the practice of psychiatric medicine has responded as much to social forces as to scientific results. Lobotomy, like the psychotropic drugs that succeeded it, was performed largely on involuntary patients in public mental hospitals. The disposition of these patients has since been decided in legislatures and courts—not in response to new scientific evidence, but because society has deemed that an individual's right to refuse mind-altering treatment is more important than any potential benefits.

Similarly, Hiatt attributes the failures of deinstitutionalization to the fact that rigorous trials did not precede the large-scale release of patients from psychiatric hos-

pitals. But pressures to deinstitutionalize derived only in part from the belief that discharge would be beneficial to patients. Other important forces included a new regard for the right of patients to leave the hospital and legislators' eagerness to save tax dollars by reducing the budgets of state mental institutions.

In his enthusiasm for change based on choice, Hiatt fails to recognize that regional planning bodies would actually represent one set of choices over others. For example, he does not consider that in allowing the authorities to control federal funds, he would jeopardize longstanding federal commitments—such as allowing citizens to choose their medical providers and giving them appeal rights if benefits are denied. Moreover, some citizens, especially the poor, seem to be better represented at the national level. For example, a 1987 study showed that recent changes giving states more control over Medicaid spending has meant benefits cuts for poor people. To what principles of equity would Hiatt's regional planners be accountable?

Hiatt also depicts the use of social-science research to change people's health-related behavior—such as convincing hypertensives to take their medication and overweight people to diet—as imposing choice over chance. True, behavior modification does diminish the role of chance, but it does not give those whose behavior is in question more choice. Instead, it serves the health professionals who define the problem and implement the solution. He suggests that the country's health-planning regions compete to have the fewest number of smokers, days of work missed for illness, and suicides. But *he* has chosen these measures of well-being, and achieving them may mean imposing his choices on others.

The book's epilogue points up the paradoxes that can result from the health-care choices that society makes. Hiatt urges that we choose two "indispensable elements of a decent health care system": preventing illness and caring for ill people. But how to reconcile these elements in dealing with the AIDS epidemic? As a venereal disease, AIDS is harder to contain than, say, cholera. Its points of transmission are legion, and only public measures that intrude on the most intimate behaviors can contain the disease.

In fact, the most effective methods of controlling the spread of AIDS—including mandatory testing, which yields large numbers of false positives, and physical isolation of infected people—would appear to be incompatible with caring for its victims. AIDS is also most prevalent among groups with low social standing. How can we distinguish preventive health measures from purely punitive efforts to change the behavior of which society does not approve?

In his effort to inspire readers to seriously consider pressing matters of health policy, Hiatt has oversimplified the alternatives of choice and chance. The scientific verifiability of our choices and the power of those to whom we relinquish them will not determine the quality of our health-care system. Rather, it is the extent to which individuals control their own lives, the equity with which health resources are distributed, and society's willingness to admit failure and keep trying that will tip the balance in favor of America's health.

SANDRA TANENBAUM is senior policy analyst in the Division of Long-Term Care of the Ohio Medicaid Administration. She is author of Engineering Disability: Public Policy and Compensatory Technology *(Temple University Press, 1986).*

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Rising Ombudsmanship, Falling Autos

The Rise of Ombudspeople

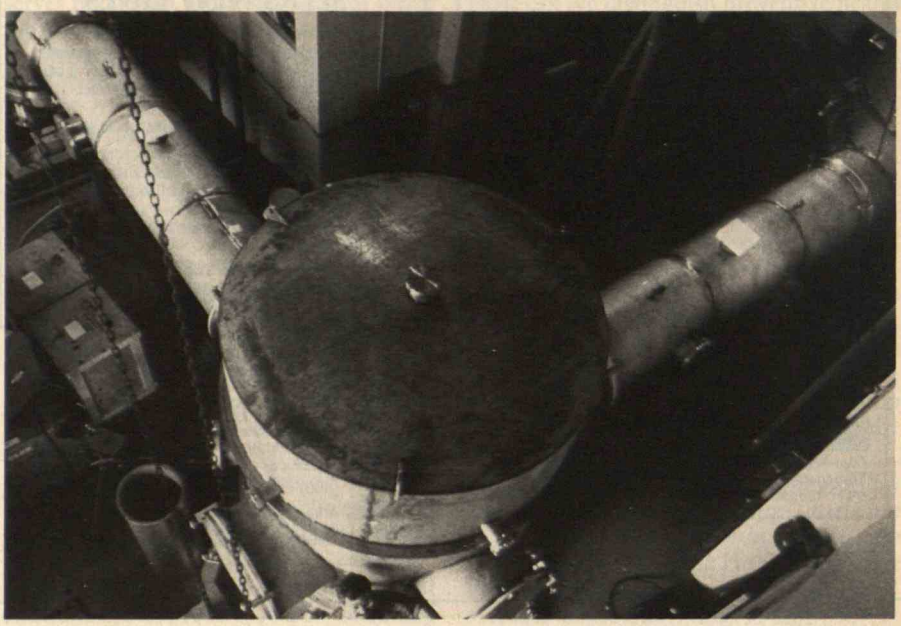
Ombudspeople are sprouting like spring flowers throughout the United States, but there is still no widely accepted job description; the concept is "very varied and currently very lively," says Mary P. Rowe, a founder of the Corporate Ombudsman Association who is adjunct professor in the Sloan School of Management.

By Rowe's definition, the ombudsperson's task is "to provide confidential and informal assistance to managers and employees on work-related concerns." The ombudsperson's office is "located outside ordinary line management structures." There are in the United States and Canada perhaps 100 ombudspeople's offices in colleges and universities and 200 in corporations, Rowe estimates.

In view of the fact that they're on company payrolls, can ombudspeople be neutral? Yes, says Rowe; the problem is "far more serious in theory than in practice because you get pushed by all sides into neutrality." Surveying her ombudspeople colleagues, she finds "relatively little stress over the issue." Most pledge confidentiality except when life or society are threatened, or serious infractions of the law are involved.

Do ombudspeople really make a difference? Most report that they have contact with 2 to 8 percent of the community they serve each year. And those that keep records say that at least half of those with whom they have worked have been "satisfied" with the outcome. Most ombudspeople can cite policy changes that result from their work, and they cite cost savings as well (keeping employees from leaving, avoiding litigation, preventing theft or sabotage, implementing employees' morale-enhancing suggestions).

But in assessing such data, Rowe warns that "no general rule holds . . . for all ombuds offices." However, she says, "the ideas of listening to people as individuals and of trying to deal with problems at an early stage are clearly of current interest to a wide variety of employers."



When a star explodes, do tiny gravity waves radiate through space like the tsunami that radiate through the seas from an underwater earthquake? Einstein predicted gravity waves as long ago as 1916, but they have never been detected. A new effort to confirm their existence will be made by M.I.T. and Caltech in the mid-1990s, using two laser gravity-wave antennas like the prototype above that is now being tested in Cambridge. Each antenna consists of several heavy polished reflectors that hang inside an evacuated tunnel. Even the slightest change in the reflectors' positions owing to a gravity wave would be revealed by laser beams shining down the tunnels. Research physicist Andrew Jeffries of the Center for Space Research is in the foreground.

The Coming Glut of American Cars

The world's capacity to build automobiles for export will rise by 2.4 million cars a year by 1990, roughly matched by worldwide demand for about 2.3 million imported cars. But much of the new capacity will build the wrong kinds of cars, and the loser in this game of Russian roulette will be the United States, says Daniel T. Jones of the University of Sussex, England, who is European research director for M.I.T.'s International Motor Vehicle Program.

Jones predicts "a serious crisis of overcapacity in North America."

According to present plans, Japanese automakers (and one Korean firm) will have invested some $5.6 billion in new North American facilities to produce at least 2.3 million cars a year. This expansion of "transplant capacity" will mean that North American factories will be able to build 4.2 million cars a year more than the United States and Canada need.

Meanwhile, Western Europe will be in a break-even situation, and Japan will be the major supplier of small cars—which the U.S. cannot make efficiently—to the Third World. Small-car demand is rising fast in these countries, which do not produce cars themselves.

A major factor in this drama, says Jones, is the program of voluntary export restraints that the United States demanded of Japan in the early 1980s. Determined to share in the profitable U.S. market, the Japanese evaded the restraints by building the new "transplant capacity" that will soon cause the glut of American-built cars.

The voluntary restraints worked against us in another way, too, says Jones. They did what they were designed to do—they returned U.S. automakers to profitability. But in doing so, they reduced the pressure for the "major structural change" that most observers believe U.S. automakers must achieve to be effective world competitors.

The necessary "new world-class levels of productivity and quality" elude General Motors in particular, says Jones, and GM will probably be the greatest victim of the forecast North American overcapacity of the 1990s.

PHOTO: DONNA COVENEY, M.I.T. NEWS OFFICE

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College graduates get Officer Candidate School leadership training, and a year of graduate-level training in the Navy Nuclear Power School.

The rewards are top-notch, too. Generous bonuses upon commissioning and also upon completion of nuclear training. Sign up while still in college and you could be earning $1,000 a month right now.

Be one of the most accomplished professionals in a challenging field. Lead the Adventure as an officer in the Nuclear Navy. Contact your Navy Officer Recruiter or call 1-800-327-NAVY.

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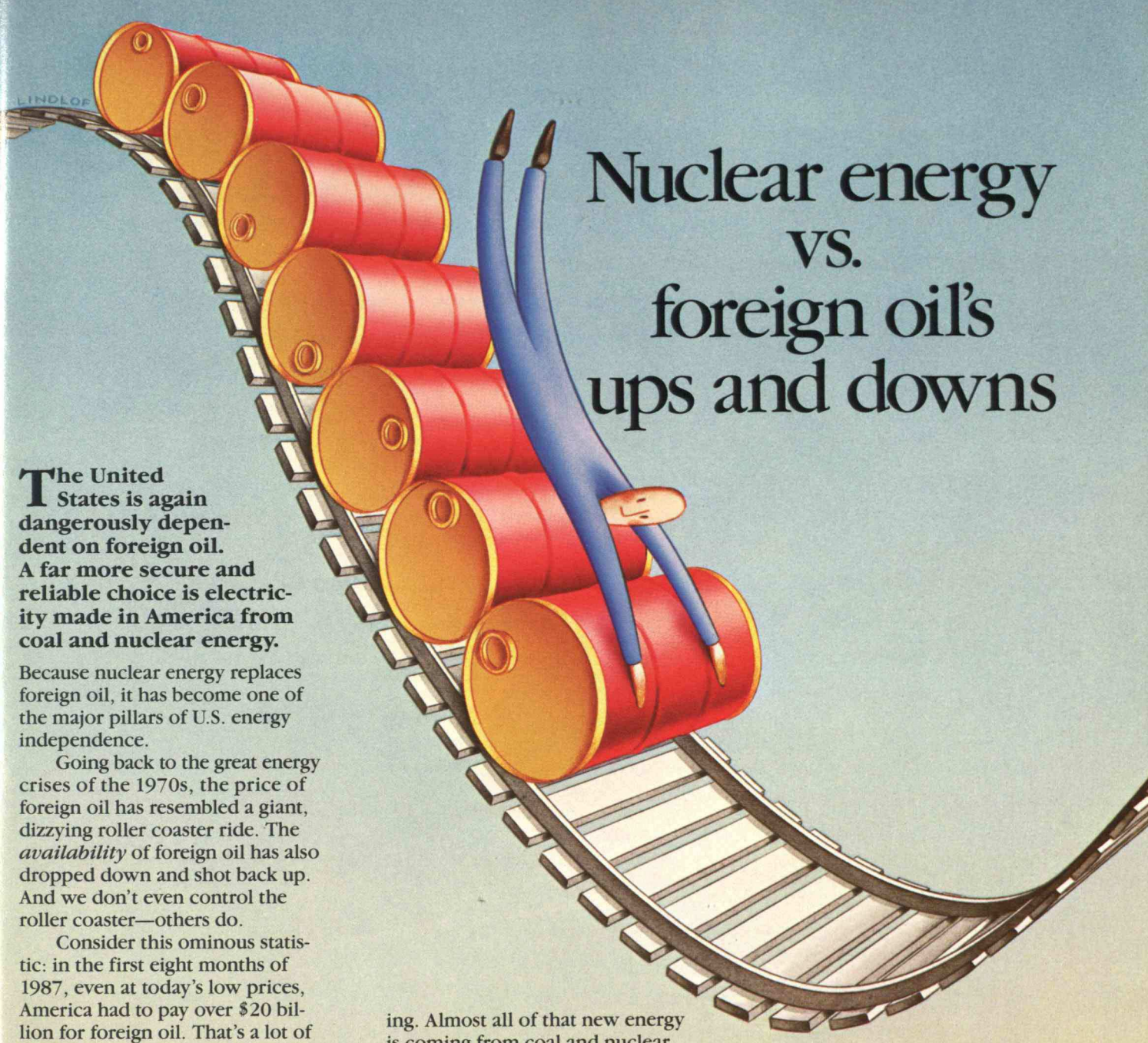
New Tax Law TIP

To help you understand the new tax law, the IRS has two new publications. **Publication 920** explains changes affecting individuals and **Publication 921** explains changes affecting businesses. Both are free. Ask for one at any IRS office or call the IRS Tax Forms number in your phone book.

TAX TIP

—A Public Service of the IRS



Nuclear energy vs. foreign oil's ups and downs

The United States is again dangerously dependent on foreign oil. A far more secure and reliable choice is electricity made in America from coal and nuclear energy.

Because nuclear energy replaces foreign oil, it has become one of the major pillars of U.S. energy independence.

Going back to the great energy crises of the 1970s, the price of foreign oil has resembled a giant, dizzying roller coaster ride. The *availability* of foreign oil has also dropped down and shot back up. And we don't even control the roller coaster—others do.

Consider this ominous statistic: in the first eight months of 1987, even at today's low prices, America had to pay over $20 billion for foreign oil. That's a lot of dollars leaving this country, adding to an already huge trade deficit.

Nuclear energy cuts oil imports

Clearly, the more energy we use in the form of electricity from coal and nuclear energy, the less oil we have to import.

Nuclear-generated electricity has already saved America over three billion barrels of oil, with billions more to be saved before the turn of the century. That's why it's so important for our energy self-reliance.

More electricity for a growing economy

Our economy needs plenty of *new* electrical energy to keep on growing. Almost all of that new energy is coming from coal and nuclear electric plants.

The truth is that nuclear energy is an everyday fact of life in the U.S. It's been generating electricity here for nearly 30 years. Throughout the country are more than 100 nuclear plants, and they are our second largest source of electric power. As our economy grows, we'll need more of those plants to avoid even more dependence on foreign oil.

Safe energy for a secure future

Most important, nuclear energy is a safe, clean way to generate electricity. U.S. nuclear plants have a whole series of multiple backup safety systems to prevent accidents. Plus superthick containment buildings designed to protect the public even if something goes wrong. (It's a "Safety in Depth" system.)

The simple fact is this: America's energy independence depends in part on America's nuclear energy.

For a free booklet on energy independence, write to the U.S. Council for Energy Awareness, P.O. Box 66103, Dept. RR19, Washington, D.C. 20035. Please allow 2-3 weeks for delivery.

Information about energy America can count on

U.S. COUNCIL FOR ENERGY AWARENESS

Remember what it was like to drive a car by the seat of your pants?

Hair flying. Heart pounding. Pulse racing. You flew. Limitations were exceeded. Expectations surpassed. You and the car were one. The same is true of the new 90 Quattro.

With permanent all-wheel drive, Quattro traction comes to grips with the road at all four wheels. The feeling of control reassuring. The performance exhilarating.

Five cylinders produce 130 HP. Sixty is reached in 8.5 seconds. Top track speed is 128 MPH. Drag coefficient a world class 0.32.

Steering is precise and quick. The basic suspension design rallye proven. The engine smooth revving. And soundly satisfying.

An Anti-Lock Braking System (ABS) is standard. Quick stops from speed are more easily controlled.

Leather sports seats hold you firmly. You ride secure. Senses alert. Every control at your fingertips. All is in harmony. You and the car are one.

Driving is what you hoped it would be. When you were a kid. In a little car. Racing down a hill.

INTRODUCING THE NEW AUDI 90 QUATTRO.

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